FIRE CONTROL NOTES

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U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE

FIRE CONTROL NOTES

An international quarterly periodical devoted to forest fire control

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The Cover:

How accurately can a smoke jumper jump?

This is a Forest Service smokejumper descending toward a forest fire in Montana.

Note steering slots at back of parachute canopy. Air escaping from the slots and three lobes or "tails" gives the jumper an 8 m.p.h. forward speed. He can make a 360° turn in about 8 seconds by pulling down on one of the guidelines (see two dark-colored shroud lines). △

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What Are Forest Service Fire Control Needs In Weather Information

Merle S. Lowden

This article is the speech given by Merle S. Lowden at the Fire Weather Meteorologists Conference, Boise, Idaho, March 1971. Mr. Lowden retired as director of Fire Control, W.O., June 1971, after 37 years of service. His leadership and devotion to fire control is well known and his clear, objective approach to fire control needs is reflected in this speech.

I can remember quite well the very beginnings of the modern national Fire Weather program. It had its early start in a meeting of the two Chiefs of the Weather Bureau and the Forest Service. At that meeting it was decided such a program would be prepared jointly. I recall being at the "end of the line" at that time and being given the assignment to head the Forest Service side of the working group.

The early plan took hold. It was a rallying point for joint efforts and seemed to catch the attention of many people, including the Congress. Additional manning and other resources were made available, and the Fire Weather Service grew. Services greatly increased in many ways, and we in the Forest Service were pleased and encouraged. However, as appropriations slowed up and increases no longer materialized, we were disappointed and somewhat discouraged. Many of the fire weather people also seemed to reflect part of this discouragement.

Essentials

Although the plan has gone through many modifications and changes, its essentials are pretty must the same: It provides a special comprehensive forecasting service for fire weather, supplemented by strong research efforts. The vital provisions of the program are more needed and pressing today than ever before. The values we protect are greater, and our people have more "know how" and, therefore, more appreciation of the value of the technology supplied to them and how they can use it.

Today

Today many of us are concerned because the forecaster is less available to our work. Rumors persist that this situation may worsen. We may inflate our importance, but we feel putting out forest fires is a special business, and we think those who provide the weather information we need and the services we require are also a "special breed of cats." We need the availability of specialists who know our job and are able to confer with us in any locality at all times of the day and night—and all days of the week during the dangerous fire season. It isn't enough just to be able to talk to a weatherman: We need someone who has studied and knows fire behavior, has been on our fires, and has seen what we do. We need someone who can speak with knowledge and experience.

At several locations where we don't have fire weather forecasters, we need them. And we need more of them at those fire weather locations already manned. We also need more mobile units.

In order to better prepare for disasters and be able to detect indices of disaster situations before they occur, we need analysis of post-situations of fire weather. A specialized weatherman can help us greatly on this. We need the advice of this skilled person at our formal fire analysis, at our wintertime reviews and planning sessions, and for individual consultations. During the next year or so, we will be making a detailed analysis of our fire problem on every National Forest, and we will be preparing specific plans for fire facilities, personnel, and actions. We'll need an increasing amount of help from the fire weathermen during this period, and we're hoping these men will be available. More assignments of fire weathermen to slash disposal projects would be extremely helpful. You're going to hear more from us on service for such operations. A man right on the ground with a mobile unit would really do a job for us. And he'd learn a lot too.

What We Want

In preparing this paper we solicited our Regions and from them we got many fine ideas of how the Fire Weather Service can be more helpful to us. And I hasten to add my commendations to those I received from the field on the service you have provided over the years. Our people are especially appreciative of the wonderful service your men gave to us on the big fire "busts" in 1970 in the State of Washington during July and August and in California during September and October.

Service has been good from the mobile forecast units at other times too, but these three special situations provided a real test of how the system works. I understand some of the units were on their way to the "bad" areas before we really got into a total fire situation. This is what we really like—you saw your duty and did it well in advance of our requests. When the situation got exceptionally bad in Washington State, I believe you had the most mobile units on fires in one State at one time in the history of your organization, and the service was superb.

Men worked exceedingly long hours and far beyond the call of normal duty. Their help was extremely valuable. But, back to our needs.

I made a recent trip through most of our Western Regions and attended fire analyses in three Regions. At these analyses, and in conversations with many of our men, I learned how much they value the Fire Weather Service and what they want to know more about. For instance, folks in the Pacific Northwest Region found rather substantial differences in the way fires burned at different times and different occasions, even though most of the usual indicators of fire spread and intensity seemed to be the same. They'd like the help of one or more Fire Weather men to study these things for that particular fire area. I believe we need more of such analyses.

When Is a Condition Critical?

We also need some studies to determine when we're at the threshold of a critical condition. In California our folks would like the Fire Weather Service to tell the public about these critical conditions and tell them why they must be particularly careful. We warn the public about these conditions, but they may get tired of hearing from us. We believe some type of alarm over radio and TV by your folks might be helpful, especially before a "Santa Ana."

In our analysis of critical fire weather situations before and after they happen, we need a more uniform approach or method. Perhaps it should be a regular, automatic procedure for the Fire Weather Service to provide us with an analysis of what happened before and during a critical fire "bust," according to a jointly agreed-to format. We need more emphasis on special alerts for approaching critical situations so we can be better prepared. Fire Weather personnel must call these situations to the attention of our men in a stronger manner, and we must respond faster.

Standardization

We still run into the request for more standardized procedures between Fire Weather Stations and, particularly, between your Regions. I realize you may not be able to cure this inter-regional problem from within this one Region, but it is still a problem to our people. The distribution and filing of 10-day fire weather records seems to vary even within a region.

A uniform and better forecast system for lightning forecasts seems particularly necessary and was asked for by several of our Regions. Since the frequency-probability system is confusing to many people, they do not know how to use it in their risk evaluations. A system that rates intensity and coverage would help.

Better and more comprehensive lightning forecasts may require much more research. It is perplexing and downright discouraging to have a lightning forecast, like you've all heard repeatedly, of "50 percent likelihood of lightning for tonight and tomorrow." Then you get

either no lightning or one of the worst storms ever to occur on the Forest!

Other Needs

New concerns of people and changing times cause new requirements in fire weather forecasting. The entire field of smoke regulation, particularly related to slash burning, has produced many new needs. Some have suggested a standard system of forecasting daily atmospheric conditions influencing smoke dispersion such as stability, upper air flow, and other pertinent information. Fire weather folks helped in developing smoke management procedures, but undoubtedly they can be improved. We need help in this continued development and in the information such development will require.

There is continued talk about fire weather forecast accuracy. Perhaps this is a "sacred cow" I should not mention, but I wonder if a uniform method of testing accuracy or a study of accuracy wouldn't help. Maybe such a system would reveal many things we could all do to help forecasts. Maybe such a study would give our men more faith in your forecasts and your men more confidence in what they predict. More faith on the part of our men should make them act more decisively. Stronger faith by both sides is badly needed.

How close are we to computer-produced forecasts for our fire weather? There seem to be many advantages to them, and we need not shy away from them, thinking a machine will replace a man. A machine must have someone to tell it what to do. Since presuppression systems use digital, fire-weather forecast input in some places, and we're going in that direction in other places, why shouldn't we be heading for digital forecasts from computers, looking to more automatic systems of the future?

It has been our desire for a long time to have reasonably priced, remote sensing equipment for Fire Weather Stations, and we've spent many dollars trying to get such a system. Other agencies are developing and working with such equipment. Wouldn't it be desirable if we had more coordination with more active Weather Service participation?

On many occasions I've pointed out the great payoff that could result from longer range forecasts. We could shift men and equipment between Regions and even from one side of the country to another. We could make our prevention program more flexible and more immediate to current needs. Our allotment of funds between areas could have greater applicability than at present. I believe we could actually save millions if we knew of critical situations accurately a week or two before they occur.

There are a number of routine procedures we need to improve through joint efforts. Some think forecasts are too long. This is a special problem where forecasts must be relayed by radio. For some locations, the period for teletyped transmission of forecasts is too short, but money may be the problem in this case.

Not Nit-Picking

I hope these suggestions on our needs haven't sounded too much like a wild dream or a laundry list of nit-picking items. We tried to develop it to be helpful, but we realize the constraints of time and funds. We know you want to do better, and we want to help.

You have our deep gratitude for all your help in the past. △

A modern national Fire Weather program must provide a "special comprehensive forecasting service for fire weather, supported by strong research efforts."

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Thermal Imagery Helps Determine How To Fight Fire

Elbert Reed

First reported on August 17, 1970, the Pumpkin Creek Fire burned out-of-control for 6 days, destroying 4,500 acres of timber and grasslands. Thermal imagery was requested the day the fire was reported, and before the fire was put out, three agencies had flown nine infra-red detection missions.

Who Flew?

The U. S. Air Force flew two missions, one on August 18 and one the next day. The Forest Service fire scan aircraft arrived late on the afternoon of August 19 and flew missions from August 20 through August 23. The next missions were flown by the Bureau of Land Management fire scan aircraft using the Bendix Thermal Mapper (BTM). This aircraft flew missions on August 26 and August 28, monitoring fire mop-up.

Upon arrival at the fire camp, imagery records were interpreted in two phases. First, an initial readout was made for spot fires outside the line. These were plotted on aerial photos and maps. The information was then passed on to division and sector bosses for action. Second, a thorough analysis of the imagery was made for the following: Changes in fire perimeter, status of spot fires previously detected, mapping of tractor-built fire lines, and mapping of burned versus unburned and partially burned areas. The effectiveness of the previous evening's back-firing could be checked through the intense emissiveness of the burning area.

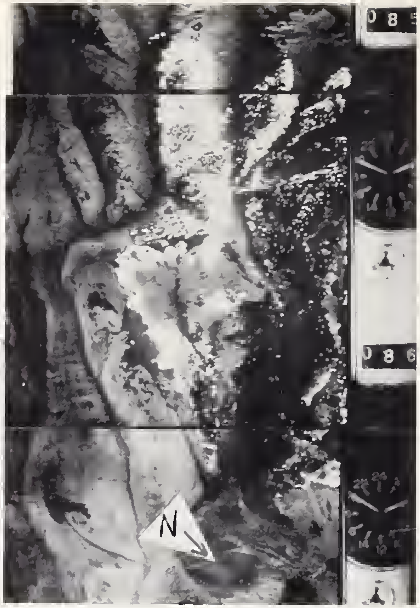


Figure 1.—Scanning mission flown by: Forest Service Fire Scan System.
Date-Time: August 20, 1970, 0430 hrs.

The effectiveness and importance of thermal imagery as a fire fighting tool are aptly demonstrated by the following situations: The morning following a blowup on the southerly line, a spot fire was detected one-quarter mile south of the line, far beyond the area ordinarily checked by ground crews. When detected, the spot was 3 square feet. It was attacked within 1 hour of detection and after about 30 minutes it was cleaned up and declared out.

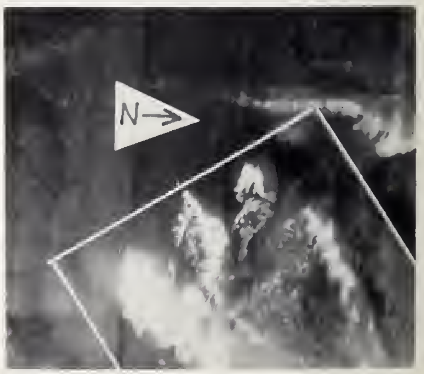
If thermal scanning had not been used, the fire boss estimated the fire would have burned one-quarter of an acre due to the location of the spot. It was estimated that this spot, under the existing burning conditions, might have increased 8 acres before control was attained. Suppression needs would have included one slurry drop, one tractor, and one inter-regional fire crew for 2 days. Estimated suppressions cost exceeded \$2500. The estimated cost of the thermal imagery mission was \$400.

Approximately 12 spot fires were detected by one or more of the thermal senors employed. These fires were controlled when they ranged in size from 4 square feet to 16 square feet. Not only did this prevent a major line loss, but it was a considerable savings of time and manpower over ground detection of these spots, many of which were putting out only whiffs of smoke. Accurate plotting of these spots enable a special 7-man team to quickly locate and extinguish them. A 25-man IR crew required for a combing operation would have been comparable.

How Sensitive Are Sensors?

This fire presented a good opportunity to compare three scanning systems. The table gives a

Figure 2.—Scanning mission flown by: U.S. Air Force, AN/AAS-18 System.
Date-Time: August 18, 1970, 0830 hrs.
Notice the same three-lobed fire pattern as in fig. 1.



Elbert Reed is staff officer to the Medicine Wheel Ranger District, Bighorn, N.F.

quick breakdown on equipment and activity, and the following paragraphs evaluate each system.

Forest Service Fire Scan, Singer System.—Of the three systems employed, this system produced the best results. When employed at altitudes of 1,500 and 3,000 feet, the scanner produces (fig. 1) imagery of such a scale that interpretation is simplified. Image resolution is quite good at both of these elevations, enabling the interpreter to differentiate between hot spots (burning fuels), forested lands, non-forested lands, burned out areas, and partially burned out areas.

This system, utilizing polaroid prints, has several advantages. The first is timeliness. Within 30 minutes of mission completion, imagery is on the ground and in the hands of the fire staff. Poor imagery, due to a number of factors, can be discarded and a rerun made immediately. Both processing problems and delay due to processing time are eliminated.

Although thermal imagery has an inherent distortion, the Singer System has a minimum amount, compared to the other two systems used.

System reliability, based on ground checks, is essentially 100

Table.—Equipment Used for Thermal Scanning and Missions Flown

Agency	Aircraft	Sensor	Night Missions	Day Missions
USAF	RF4C	AN/AAS-18	0	2
USDA FS	Beach Queen Air	Singer	4	1
USDI BLM	Unknown	Bendix	1	1

NOTE: Night missions include those at dawn when solar interference is negligible.

percent. Spot fires, approximately 2 square feet, burning in duff with little or no smoke, were detected. The Singer System effectively met all criteria.

U.S. Air Force, AN/AAS-18 System.—This system was used at a flight altitude of 8,000 feet, producing a scale somewhat smaller than that of the Forest Service Singer System. Resolution is comparable to the Singer System and distortion is minimal.

The only defect noticed on this imagery is "ghost" haze along the scan lines on that portion of the imagery covering the extremely hot areas of the fire. Interpretation of hot spots posed no problem. Differentiation of forested lands, non-forested lands, burned out areas, etc. was difficult (if not impossible), due to the "ghost" haze mentioned above.

The greatest problem we encountered with use of the Air Force sensor was the time delay. In one instance 24 hours elapsed from mission completion until the fire staff received the imagery. Six hours of this was due to Air Force flight and processing time. The rest was due to ground travel and administrative holdup. During the early stages of a fire, immediate (2 hours maximum) receipt of the imagery is a necessity.

USDI, Bureau of Land Management, Bendix Thermal Mapper.—This system provided the least effective thermal imagery support. Flight altitude was 1,000 and 3,000 feet. At both altitudes, a scale similar to that of the Singer System was produced. Resolution was very poor. Scan lines were often quite heavy, obscuring the terrain map.

Interpretation of forest lands and non-forest lands was possible, but very difficult. Hot spots were quite readily picked up; reliability was about 60 percent. Ground checks of several indicated hot spots revealed nothing. A partial cause of this unreliability was due to the processing: Dirt or some foreign matter was on the film plane, the light source was directed against the film plane, or foreign matter got into the processing during development. Extreme distortion characterized this imagery and made plotting difficult.

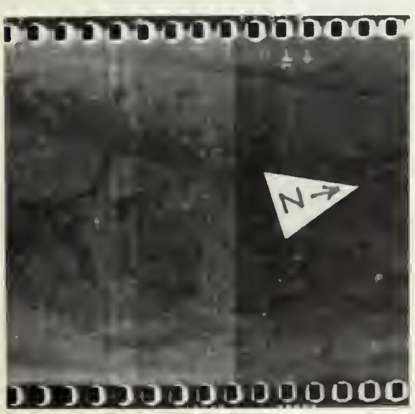
Delay between mission completion and ground delivery was usually about 4 hours. This is sufficient for mop-up operations on which the sensor was employed, but not sufficient for a fast-moving fire.

Imagery Is Versatile

Thermal imagery can be put to a number of uses in fire control. Primary is the detection of burning fuels and perimeter mapping. Rapid and accurate mapping of burned areas, partially burned areas, unburned areas, and location of tractor lines can be done.

This report was written to assist fire control personnel in the effective use of thermal mapping systems. The suggestions are those of the author based on discussions with the fire staff and pilot of the Forest Service fire scan aircraft, personal observations, and previous experience with using and reading out military thermal sensors. △

Figure 3.—Scanning mission flown by: Bureau of Land Management, Bendix System.
Date-Time: August 28, 1970, 0500 hrs.



Small Airport Handles GIANT Mobilization

Francis B. Lufkin and William D. Moody

This article describes the impact of a fire bust on the North Cascades Smokejumper Base facility, its organization and its individual air operations. This article also outlines the safe and efficient, major-scale aerial operation which evolved.

Nestled in the Methow River Valley, on the Okanogan National Forest in North Central Washington, is the North Cascades Smokejumper Base (NCSB). It is normally a 36-man, 2-airplane Forest Service airport. It lies at 1,650 feet elevation and has a single, hard-surface, 5,000-ft.-long runway.

From July 16-31, 1970, NCSB became a major multi-function air, service, and supply, mobilization-demobilization center, operating around the clock. More than 350 people and over 50 aircraft were assigned to the total operation during the peak of the activity.

Smokejumper Force Grew

By the third day of the bust, the smokejumper force at NCSB grew to 176 men. Smokejumpers from every smokejumper unit in Regions 1, 4, 5, and 6 participated. In the first 4 days, July 16-19, 329 fire jumps were made.

Francis B. Lufkin is aerial project officer, North Cascades Smokejumper Base, Okanogan National Forest. William D. Moody is at the North Cascades Smokejumper Base.

Between July 15 and 27, 496 jumps were made on 85 fires, with a record 103 jumps made on July 16. The smokejumper demand was so great NCSB was out of jumpers several times during the first 8 days of the bust.

A high percentage of the jumps were made in extremely rugged country, under adverse wind and fire conditions. In spite of this and in spite of tremendous fatigue, only one serious and three minor jump injuries occurred.

3,000 Firefighters Arrived

Because it was close to fires on the Okanogan National Forest, NCSB became the logical mobilization-demobilization center for more than 3,000 firefighters.

After arriving at Moses Lake on large jets, the firefighter crews were shuttled to Omak, Wash., and NCSB by a fleet of DC-3's and DC-4's. Most crews were fed and bedded down at NCSB while waiting to transfer to fires or, later, waiting for demobilization aircraft. The NCSB messhall served 8,700 hot meals during one 10-day period.

Air Traffic Was Tight

For several days, air traffic at NCSB exceeded that of Spokane International Airport. Between July 16 and 19, 1,150 takeoffs and landings were made on NCSB's 5,000-ft. bituminus-surfaced airstrip. All air traffic advisory communications were handled by the NCSB dispatcher using Okanogan Forest Net, Airnet, or Unicom 122.8 mc. frequency. On the fifth day, a temporary FAA air traffic control station, operating out of the back of a pickup truck, was set up; it operated 24 hours a day. This was done because, while the Forest Service could not authorize straight-in landings and takeoffs, the FAA controller could. This traffic control station made possible more takeoffs and landings and eliminated aircraft "stacking" overhead.

Total air traffic between July 16 and 31 was recorded at 3,700 takeoffs and landings, all without incident. Temporary field lights permitted 24-hour airport use. Aircraft assigned to the fire included six smokejumper-cargo-dropping aircraft; eight DC-3's, one DC-4, and one C-46 passenger-freight transport aircraft; five air-attack lead planes; four aerial detection planes; and a fleet of small aircraft used for special missions and passenger haul. All fixed-wing, aerial-retardant aircraft operated out of Wenatchee or Omak airports, not NCSB.

Helicopter Operation

At the peak of activity, 23 helicopters, including six heavy turbines, were assigned to NCSB to form a helicopter pool. Priority jobs were assigned by General Headquarters and were handled by 39 heliport personnel. In the course of the bust the helicopters transported 10,201 passengers and 459,037 lbs. of cargo, dropped 860,320 gallons of water or retardant, and made several rescues of trapped or injured firefighters. All missions totaled 1,480 actual flight hours at the cost of $642,386. There were no accidents or reports of damaged equipment.

Fire Cache Grew, Too

Just as NCSB became the major manpower supply depot, it also became the major service and supply center for the western Okanogan National Forest. By truck, helicopter, and parachute hundreds of tons of supplies were delivered to fire camps from NCSB. Large helicopters played an important role in the delivery of much of the cargo.

Resupplied from the cache at Wenatchee, the 300-man Okanogan (NCSB) cache operated 24 hours a day. As the Wenatchee cache inventory drew down, NCSB ordered direct from GSA; private suppliers; Region 6 Fire Cache at Redmond, Oreg.; and from other out-of-the region caches.

After the crisis was over, NCSB again processed fire cache supplies and became the major center for all cache items being returned to Regional fire caches. Supervisory smokejumper and NCSB warehouseman, Terry McCabe and his crew, received, sorted, inventoried, weighed, and prepared supplies for delivery back to the Regional cache. Priority items such as radios were immediately returned to respective caches by airplane. This phase of NCSB's activity continued on a major scale until mid-October.

Organize! Organize!

With a fire bust and air operations of this scale, people arrived from all over the United States. It became necessary, for the sake of safety and efficiency, to reorganize the basic NCSB organization. By the fifth day of the fire bust, the "new" organization evolved (fig. 1). Listed below are a few of the key positions.

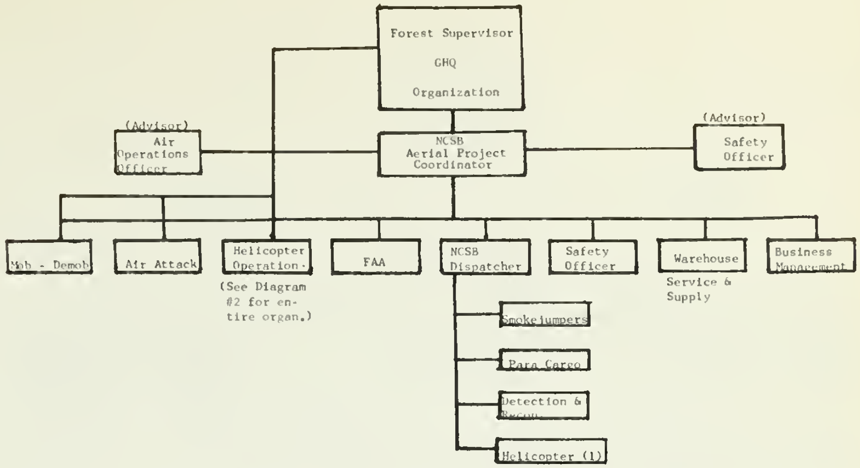


Figure 1.—This is an organization diagram of the interim North Cascades Smokejumper Base (NCSB).

1. *Aerial Project Coordinator (APC):* NCSB's aerial project officer, Francis B. Lufkin, coordinated and managed all aerial project activities. In addition, he acted as liaison officer between incoming crews and the local community.

2. *NCSB Air Operations Officer (AOO):* This man, John Cowan, was responsible for aircraft safety, regulation enforcement, and wise and efficient use of all aircraft.

3. *NCSB Safety Officer:* A safety officer on a project of this size was a must. NCSB's, "Ole" Olsen, advised the AOO and APC on the overall safety of the operation. The organization operating under these positions is shown in figure 1. Figure 2 shows the organization of the helicopter operator.

Recommendations for a Safe and Efficient Air Operation

1. Establish an organization to insure the safest and most efficient total operation under *your* unique circumstances. Consider these key positions:
   a. Aerial project coordinator.
   b. Air operations officer.
   c. Project safety officer.
   d. Other experts for specific operations (such as local geography and weather conditions).

2. If you have heavy air traffic, consider setting up a temporary FAA air traffic controller.

3. Anticipate aircraft fuel needs, both quantity and type, including special helicopter fuels. Try to order at least 24 hours ahead of time.

4. Contract fuel trucks for aircraft refueling. This cuts down on gas pit congestion and delay.

5. Broadcast airport restrictions due to air traffic congestion, weather and visability problems, etc.

6. Gear your operation so phases do not impact each other. Assign qualified personnel to every operation, and operate 24 hours a day if necessary.

7. Anticipate and order special personnel to facilitate safety and efficiency. These people are valuable:
   a. Parachute riggers and repairmen.
   b. Cargo handler and cargo droppers.
   c. Gassing crews—24 hours a day.
   d. Loading and unloading crews (including a large forklift with operator).
   e. Business-personnel management people to handle

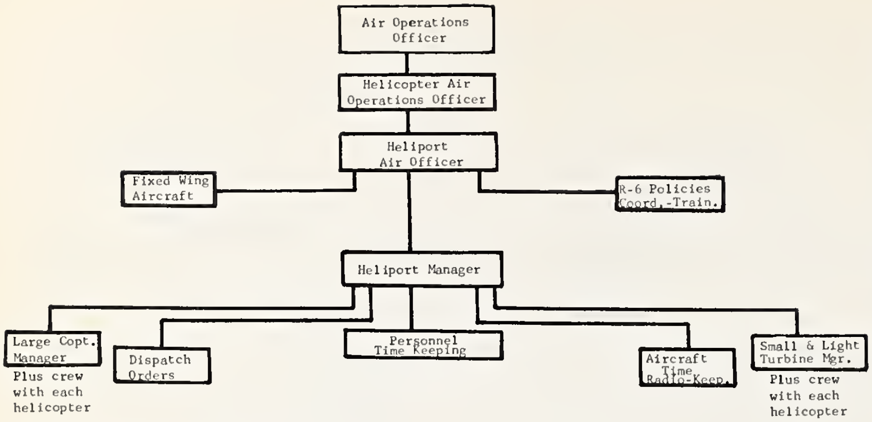


Figure 2.—This diagram shows the NCSB heliport organization.

time reports, accident reports, etc.

f. Carpenter.

g. General maintenance man.

h. Local service and supply and procurement personnel. These people are valuable in filling emergency orders from local sources for trailers, portable toilets, communications, etc.

9. Develop a communications link between all project operations. Provide enough phones and trunk lines so that all operations have good communications with the outside local fire organization.

10. Provide facilities for each operation. Identify them with signs. Eliminate congestion and conflicting "flow patterns."

11. Establish an information desk.

12. Anticipate and "be prepared" to handle and schedule routine daily activities such as personnel movement, air drops, etc.

13. Pre-train crews to perform warehouse-fire cache work including helicopter-paracargo cargo handling.

14. Provide fire protection for all facilities, operations, and aircraft. Contract for local rural fire department equipment that can use foam fire retardant.

15. Consult the FAA Engineers for recommendations concerning safety procedures, etc. after estimating what the air traffic impact will be.

16. Provide adequate signs to keep unauthorized ground equipment and personnel away from aircraft and operations areas and off runways. Make use of local law enforcement officers if necessary.

17. Set up food-preparation facilities and outdoor coffee stands. Consider use of frozen meals and rations for emergency situations.

18. Order commercial, portable chemical toilets to supplement "indoor" facilities. Place some near crew loading-unloading areas.

19. Provide ground transportation for aircraft crews and other overhead to motels and restaurants. Consider rental cars, etc.

20. Have a liaison officer working between local, Forest, aerial project coordinator (APC), incoming crews, and local community.

21. Provide aircraft parking areas for aircraft out-of-service due to pilot, flight-time restrictions, needed repairs, waits for crews or equipment, etc.

Smokejumper Recommendations

1. Thoroughly brief all incoming jumper crews of unit policies and procedures, fire situations, facilities, etc. Issue special equipment as needed.

2. Have home-unit spotters spot or supervise all smokejumper missions.

3. "Ground" jumpers, pilots, or spotters, when they are overly fatigued.

4. Keep spotters and jumpers current on fire weather and other conditions in the area.

5. Do not let spotters be tempted to deviate from standard practices and safe procedures.

6. Be sure spotters hold short safety meetings periodically to discuss jump and fire conditions and problems encountered. Remind the crews of safety objectives and of safety measures that compensate for fatigue and complacency.

Helicopter Recommendations

1. Keep operation area as dust free as possible. Initiate dust abatement measures early.

2. Enforce use of all helicopter-operation safety equipment.

3. See that helicopter operations are directed by heliattack-qualified personnel.

4. Anticipate the need for special fuel, such as turbine fuel.

Summary

The July 1970 Okanogan National Forest fire bust became a major impact on the North Cascades Smokejumper Base. Through teamwork, dedication to the task, and cooperation, the organization at the small airport handled a giant mobilization efficiently and safely.

Perhaps this experience and these recommendations will be of value to you if you should ever become involved in a similar major aerial fire suppression operation. △

Probability Forecasts Need Revision

Robert E. Lynott

A simple aspect of probability forecasting for weather is "probably" overlooked by many forecasters and users of the forecasts: Are such forecasts revised as frequently as needed?

A probability forecast is the evaluation of weather conditions existing at the *particular time* of the forecast. At any later time, that evaluation can usually be revised.

Regardless of the numerical value used for the stated probability, 10-percent chance of rain, for instance, the predicted event either does or does not occur. Perfect forecast accuracy is attained only in two combinations of circumstances, when a forecast of 100-percent probability is followed by occurrence or when a forecast of 0-percent probability is followed by nonoccurrence.

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Degree of Accuracy

Because perfect forecast accuracy is not attainable for weather events, values between 100 and 0 are predicted. This is tacit admission that absolute accuracy is not possible. Nevertheless, the intermediate values are useful in a statistical sense. The user can take or forego action on the basis of his cost-benefit ratio.

An evaluation of the accuracy of probability forecasts is meaningful only if a large number of forecasts are evaluated. A single forecast cannot be evaluated by itself unless it is a "yes" or a "no" forecast.

Proper attention to the time factor must not be neglected in the use of probability forecasts. Usually, current weather conditions can be monitored continuously by a forecaster from the time of the original forecast until the forecast period expires. Assuming such monitoring, and assuming that forecast accuracy improves as the time period decreases, it becomes a general truth that any probability forecast can be successively revised until it reaches the perfect accuracy of either 100 percent, occurrence, or 0 percent, nonoccurrence.

The question for all concerned is whether such revision is being done whenever appropriate, that is, when sufficient use can be made of the revised values, at points in time nearer to the end of the period. Users may mistakenly assume that such improved revisions are not possible. Forecasters may mistakenly assume that users use revisions for shorter periods. Then again, there are circumstances where frequent revisions of forecast probability are not practical or useful.

But forecast users should review all pertinent operations. They should consult with forecasters about possible opportunities for this aspect of probability forecasting.

For Instance

With respect to the occurrence of lightning in Oregon and Washington, the actual incidence of thunderstorms is important enough to fire control personnel that such reports are immediately relayed by teletype to all appropriate National Forests and other management units; in so doing, the probability forecast is revised. Lightning changes the actions of the forecast users even on very short advance notice. In effect, lightning in an adjacent area causes the *user* to revise the probability in his area to a high number, say 90 percent, regardless of the earlier probability forecast.

Perishable Forecasts

The purpose of this discussion is to remind forecast users that probability forecasts are extremely perishable. They can be revised by weather forecasters to approach 100 percent or 0 percent as time progresses. Would such revision be useful to you? △

Computer Simulates Fire Planning Problem

Robert L. Bjornsen and Richard A. Chase

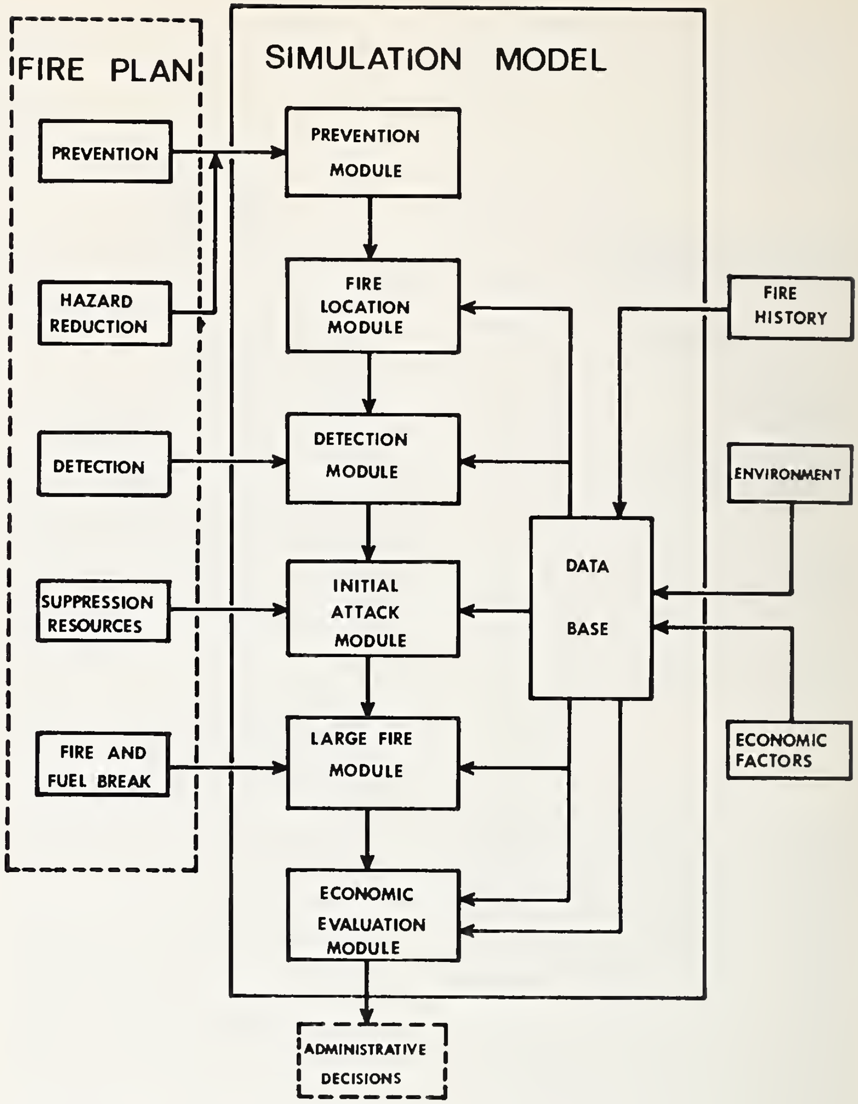
Are you a "what if" fire planner? How many times have you speculated: What if I introduce a new prevention program or change from fixed to aerial detection or redeploy initial attack forces or build a network of fuel breaks? Will it reduce fire occurrence and damage? If so, what are the probable economic consequences of the alternative selected?

Simulation: Modeling Reality

What you need is a better way to predict the probable consequences of available alternatives, a way which avoids the pitfalls of guessing but does not involve the costs and delays of experimentation and pilot testing. Simulation is an answer, and FOCUS,[1] the Fire Management Systems project at the Riverside Fire Laboratory, is our simulation model.

With simulation, planners and managers can propose changes and test ideas with no risk. The probable long-term consequences of alternative courses of action can be compared because simulation allows components of the system and their relationships to be changed to reflect the introduction of new equipment, new techniques, and different configurations.

Through use of a large modern computer, which can perform many thousand calculations a second, the operation of a system can be repeated many times in a few minutes. This process permits variability found in the "real world" and permits some feeling to be gained for the most likely consequences of a given alternative. Since many years of operation of a system can be simulated in a relatively short time, the manager can quickly receive an objective analysis of probable long-range strengths and weaknesses of alternative courses of action. Armed with this knowledge, he is in a much better position to make a good decision than if he were forced to use only his own judgment.



Simulation model design and flow

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[1] Fire Plan Operation Characteristics Using Simulation

Model Design and Operation

The components and operation of the simulation model are shown in the figure. To work with the model the fire planner specifies prevention and hazard reduction programs; the detection system; the kind, amount, and location of initial attack forces; dispatch decision rules; and fire and fuel break systems. Thereafter the plan will be tested against a series of simulated fires to find potential weaknesses and predict economic consequences.

For each fire tested, the model will calculate travel times of various forces (ground and air) dispatched to the fire. It will then compare their fireline production rates with the fire's rate of perimeter increase from time of arrival, and will determine if available initial attack forces can contain the fire and at what size. The model will also determine size of those fires escaping initial attack and will evaluate economic consequences of the resulting large fire according to resources involved and probable fire intensity.

Data Makes It Run

A data base provides the model with information necessary to simulate its particular fire problems. From data stored on past fire occurrence, risk, weather, fuels, and topography, the model generates realistic lightning and man-caused fire starts (see figure). Until effective control action contains each fire generated, the fire size increases at a rate consistent with the given fuel and slope and the probable fire danger expected at the time.

Other data base items include types and locations of permanent fire control facilities, locations of and travel times over the transportation system, and any constraints which physical conditions or management policy may impose on use of certain equipment, tactics, etc. in any location. Also stored are data relative to potential resource damages.

FOCUS Today

Employing a team of operations analysts, mathematicians, and foresters, early development work on FOCUS has concentrated mainly on fire location and initial attack modules and on data base design. Preliminary working versions of these are being evaluated using data from a test area on the Tonto National Forest, Arizona. Meanwhile, only lightning firepatterns are being tested in the simulation process. Man-caused fires present a more complex problem in prediction, and the development of sound statistical approaches to their use has proceeded at a slower rate.

Pending development of a model for predicting actions of large fires, determination of final size and shape of those fires escaping initial attack will probably be based largely upon previous experience with class C and larger fires.

When fully developed, FOCUS will be able to simulate fire problems of a particular area and evaluate probable long-term effects of various protection plans. FOCUS will provide the planner with some feel for the strengths and weaknesses of alternative plans and permit him to see how innovations will affect patterns of fire occurrence and fire escapes. Ultimately, FOCUS will also give a measure of the net economic consequences to be expected from a particular alternative and thus provide a rational basis for the justification of budget requests and for allocation of funds. △

Automated Fire-Danger Rating Works

Howard E. Graham

The Pacific Northwest Federal Agencies have an operational automated fire-danger rating procedure that solves the problem of data analysis and data display and provides uniform accurate computations. This article describes the benefits and the procedure.

The Pacific Northwest Region of the Forest Service, together with several cooperating agencies, has solved many fire-danger data management problems related to fire danger ratings. This was done by developing an automated procedure.

Some of our problems were:

1. Fire Control units and fire-weather forecasters frequently arrived at different conclusions concerning the magnitude of current conditions.
2. Fire-danger ratings were often inconsistent from area to area. The weather at any one place is always related to nearby weather, but some of the ratings did not reflect this principle.
3. Headquarters units, such as the Regional Office, had difficulty maintaining awareness of fire danger.
4. It was virtually impossible to determine accuracy of fire-weather forecasts.

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How Automation Works

Prerequisites

In the Pacific Northwest, several steps were taken to remove all possible error from the process involved in applying observed weather and weather forecasts to presuppression. These steps were considered necessary before an automated data management procedure could be developed:

1. *Weather zones defined.*—Fire-weather forecast areas were defined to conform primarily to weather zones instead of administrative boundaries. There was a rational basis for this: On most fire season days, the weather condition is usually the same over extensive areas of similar elevation, topographic type, and cover type. Reasonably homogenous fire-weather conditions, hence, fire danger, with the possible exception of human risk, are to be expected within each zone. The forthcoming National Fire-Danger Rating System (NFDRS) calls for zones. Any new zones should be established according to NFDRS guidelines.

2. *Forecast and rating elevation defined.*—A forecast and fire-danger rating elevation was defined for each zone at approximately the mean elevation. Fire weather is predicted and fire danger is computed for this forecast and rating elevation. The advantages here are that both the weather forecaster and the user are aware of specific targets for forecasting weather.

3. *Location of fire-danger stations.*—Fire-danger stations are generally located within 1,000 feet of the zone forecast and rating elevation and spaced as evenly as possible around the zone center. To determine a reliable measure of current conditions and to provide forecasts for the mean elevation, weather data that directly measure the well-exposed mean conditions are needed. Lack of properly located observation stations creates a distinct handicap in attempts to compare actual and predicted fire weather. Consequently, special efforts were to provide properly located weather stations.

4. *Reliable communications system.*—A rapid and reliable communications system is essential. Region 6 and the cooperating agencies have teletype communications that can be scheduled to meet the needs for this automated procedure.

Data Flow

Observed fire-weather data are transmitted to the computer. Some of these data are from automatic telemetering stations and some from manual stations. The computer analyzes the observed data and issues current zone weather averages. Using these data as starting points, fire-weather forecasters issue values of expected weather by zones. The computer converts these predicted weather elements to predicted burning index. At the same time, the predicted values are summarized as needed and automatically addressed to users. Each predicted zone burning index is automatically checked against frequency of occurrence tables. When an unusually high burning index is predicted, a special alert is issued calling attention to the situation. Examples of the two types of special alerts issued are below:

1. "Special Alert—Predicted BI for zones listed below have occurred on the average of 5 percent or less of the days July-September 15, 1961-1968."

2. "Special Alert—Precicted BI for zones listed below exceeds any previous observed BI July-September 15, 1961-1968."

Advantages of Automation

The automated procedure has two significant advantages. It allows the management of the large quantity of data to become systematic, and it produces data analyses and data displays never before available.

Data Analyses

1. *Analysis of observed data.*—The process of determining predicted fire danger first involves determining current conditions. An individual weather observation does not, by itself, provide a very accurate indication of the area-wide current weather needed for presuppression planning. Current conditions are best indicated by an integration of several observations. Following this principle, we have developed a procedure for statistical analysis that determines current conditions by weather zones. Conditions defined are zone averages of temperature, relative humidity, wind speed, precipitation, buildup index, and burning index. All analyses are done accurately and uniformly regardless of location or the Federal agency involved. The result of this systematic procedure is much more useful because it provides a complete Regional view, area by area, and provides logical connection between adjacent areas.

2. *Provides data summaries.*—Not only is fire danger determined by weather zones but summaries of fire danger are produced for broad sections of the Region. The summaries provide a broad overview for the Region's fire control operations.

3. *Verification studies.*—Up to now, little has been known about the improved protection that could be obtained through use of the morning forecast in-

stead of the previous afternoon forecast. But we will soon know because forecasts are being verified. Other questions that apply to protection problems need to be answered; for example, what success does the forecaster usually have in predicting marked weather changes. Forthcoming answers to these will benefit the fire control effort. Some fire control systems may need to be redesigned to fit the forecast accuracy.

Data Displays

1. *Comparison of observed and predicted values.*—What conditions were forecast and what actually happened? This information is displayed daily on teletype shortly after basic observation time. Listed by weather zones are both current zone weather averages and predicted values (fig.). Thus, all user agencies and forecasters have ready access to comparative values of what was predicted and what actually happened. For the first time forecasting accuracy can be determined.

Teletype display of observed and predicted conditions.

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M
1455 PDT 08/23/70 - PREVIOUS FCSTS AND CURRENT OBSVD FDR AND WEATHER.
OBSVD DATA 1400 PDT TDA - DATA ARE ZONE - 24 HR AVG RAIN - CURRENT BUI.
YDA AFTN FCST TIME - FCST COMPARED TO AVG OBSVD - BI-TEMP-RH-WIND.
THIS MRNG FCST TIME - FCST COMPARED TO AVG OBSVD - BI-TEMP-RH-WIND.
.
SALEM FCST RESPONSIBILITY    .
312-000-104--1500-0400-064054-6894-1208--0800-0400-064054-6894-1008.
313-001-100--1500-0300-063058-6983-1007--0800-0400-063058-6883-0907.
314-001-132--1500-1100-068055-5892-0705--0800-1100-066055-6092-0805.
316-000-160--1500-1301-080061-5282-0606--0800-1101-072061-5482-0506.
317-001-064--1500-0901-068064-6079-0805--0800-0901-066064-6279-0805.
320-001-080--1500-1000-065057-5881-0705--0800-1000-065057-6081-0805.
MEDFORD FCST RESPONSIBILITY  .
302-000-223--1500-2110-076066-4060-0706--0800-1810-074066-4560-0706.
303-000-280--1500-3031-084079-2623-0808--0800-2831-082079-3023-0808.
305-000-228--1500-2929-085083-2423-0707--0800-//29-///083-//23-//07.
306-000-236--1500-3134-082080-2418-0808--0800-//34-///080-//18-//08.
329-000-357--1500-3746-085084-1714-0912--0800-//46-///084-//14-//12.
330-001-354--1500-3851-087086-1513-0914--0800-//51-///086-//13-//14.
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PORTLAND FCST RESPONSIBILITY .
307-000-230--1500-2830-078078-3427-0908--0800-2730-076078-3227-0808.
308-000-231--1500-2835-081081-3425-0910--0800-2935-082081-3225-0910.
322-000-215--1500-2225-078079-3932-0707--0800-2025-076079-4332-0707.
323-000-233--1500-2828-075079-2930-0808--0800-2828-076079-2730-0708.
324-000-201--1500-2220-078078-3942-0707--0800-2020-076078-4242-0707.
325-000-200--1500-2217-078075-3949-0708--0800-1917-076075-4349-0708.
326-000-241--1500-3028-082083-2734-0809--0800-3128-084083-2434-0809.
327-000-347--1500-2531-086090-2325-0505--0800-3731-094090-2425-0705.
328-000-319--1500-3040-082086-2216-0710--0800-3740-090086-2316-0710.
390-000-196--1500-2112-080075-4452-0905--0800-2012-077075-4752-0905.
425-000-138--1500-2916-080077-3046-0906--0800-2716-080077-3046-0806.
426-000-248--1500-3123-083080-2342-0809--0800-2823-083080-2942-0809.
427-000-122--1500-2418-083079-3746-0908--0800-2118-082079-4046-0808.
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PENDLETON FCST RESPONSIBILITY.
331-000-366--1500-//43-///088-//14-//11--0800-//43-///088-//14-//11.
332-000-283--1500-3127-086085-1518-0605--0800-//27-///085-//18-//05.
333-000-262--1500-3844-094091-1522-0609--0800-//44-///091-//22-//09.
334-000-230--1500-2930-085087-1816-0606--0800-//30-///087-//16-//06.
336-000-276--1500-3335-087086-1516-0708--0800-//35-///086-//16-//08.
337-001-302--1500-3633-088087-1514-0807--0800-//33-///087-//14-//07.
338-001-278--1500-4337-083079-1817-1209--0800-//37-///079-//17-//09.
339-000-294--1500-4036-095095-1619-0706--0800-//36-///095-//19-//06.
340-000-196--1500-2733-089090-1818-0505--0800-//33-///090-//18-//05.
341-000-197--1500-3132-084085-1816-0707--0800-//32-///085-//16-//07.
342-000-186--1500-2933-086085-1815-0607--0800-//33-///085-//15-//07.
343-000-146--1500-3238-085086-1613-0709--0800-//38-///086-//13-//09.
344-000-126--1500-3637-079081-2017-1010--0800-//37-///081-//17-//10.
345-000-238--1500-3728-095097-1717-0603--0800-//28-///097-//17-//03.
346-000-163--1500-2937-085088-1815-0609--0800-//37-///088-//15-//09.
```

2. *Predicted burning indexes.*—Predicted burning indexes by zones are displayed on teletype in map form twice daily to all offices. Through use of a transparent overlay, the user has a quick visual plot of weather zone burning index over the States of Oregon and Washington. (See *Fire Contr. Notes,* 31(4):12, 1970.)

Benefits to You

Certain benefits from this automated procedure can be recognized immediately:

1. It eliminates much ambiguity about weather conditions. The new, more homogenous weather zones, with their defined forecast and fire-danger rating elevations and with their more representative observation stations, provide the forecaster and forecast user alike with a specifically defined frame of reference.

2. It reduces fire control work load. Less communication and less manipulation of weather data is required.

3. And, most important, it performs these processes uniformly and accurately.

The automated procedure incorporates a number of successfully tested procedures into an effective fire control manager's tool. This type of streamlining is necessary to provide the best presuppression protection and to get the most out of the new National Fire-Danger Rating System—or any fire-danger rating system for that matter. △

U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

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United States Department of Agriculture

1971 . . . Commemorative Year Of America's Most Disastrous Forest Fire

Many Americans know of the disastrous Chicago Fire, but few know of the Peshtigo Fire — America's most disastrous forest fire. Both fires occurred on October 8, 1871. Two hundred lives were lost in the Chicago Fire; 1,300 lives[1] were lost in the Peshtigo Fire; 2,240 acres burned in the Chicago Fire; 1,280 thousand acres burned in the Peshtigo Fire.

Dry Weather

The unusual climatic conditions accompanying these fires should be noted because they could occur in the future: (1) Below-normal precipitation for 3 to 8 months, (2) low vegetation in draught or wilting stage for 1⅓ to 2½ months, (3) long-term below-normal humidity, and (4) above-average sunshine duration. The daily weather patterns that preceded these fires were not unique.[2, 3]

A Legal Consequence

The Peshtigo holocaust forcibly brought the seriousness of the forest fire menace to the attention of the public. The result was a law (CH. 285, Wis. Laws of 1873) prohibiting burning in woods, prairies, or in cranberry bogs between August 1 and November 30. This law served to establish the principles of a closed season on burning in Wisconsin.[4]

Peshtigo Today

Peshtigo, Wis., has become a thriving manufacturing center. The forest has grown back and is providing raw material for industry and a place for relaxation and recreation. The community has issued a Peshtigo Fire Centennial Coin depicting the city reborn from the ashes of America's most disastrous forest fire.

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[1] R. W. Wells. Fire at Peshtigo. Prentice-Hall, Englewood, N.J., 243 p., 1968.

[2] Donald A. Haines and Rodney W. Sando, Climatic conditions preceding historically great fires in the North Central Region. USDA Forest Serv., N. Cent. Forest and Range Exp. Sta., Research Pap. NC-34, 19 p., 1969.

[3] Donald Haines and Earl L. Kuehnast. When the Midwest burned. Reprinted from Weatherwise, vol. 23, no. 3, June 1970.

[4] J. A. Mitchel and Neil LeMay. Forest fires and forest fire control in Wisconsin. Wis. Conserv. Comm. in coop. with USDA Forest Serv., 75 p., 1952.

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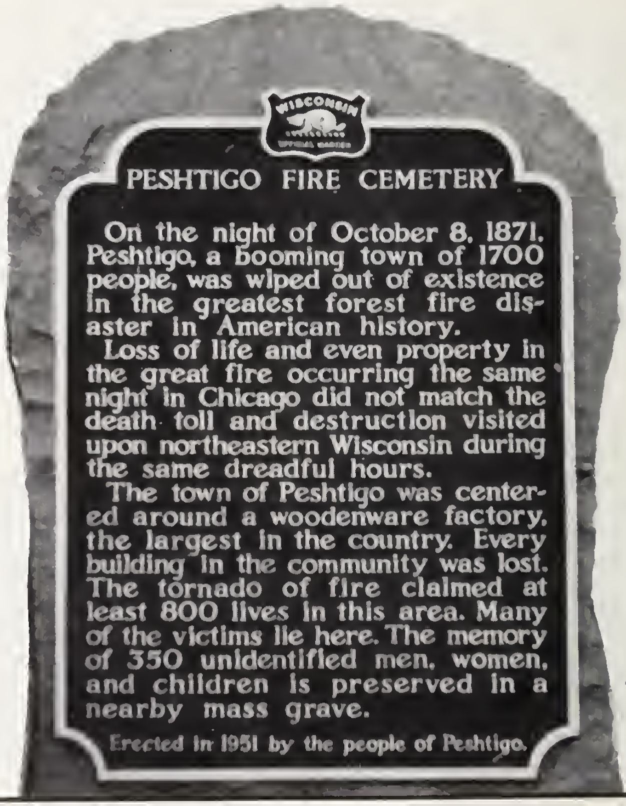

FIRE CONTROL NOTES

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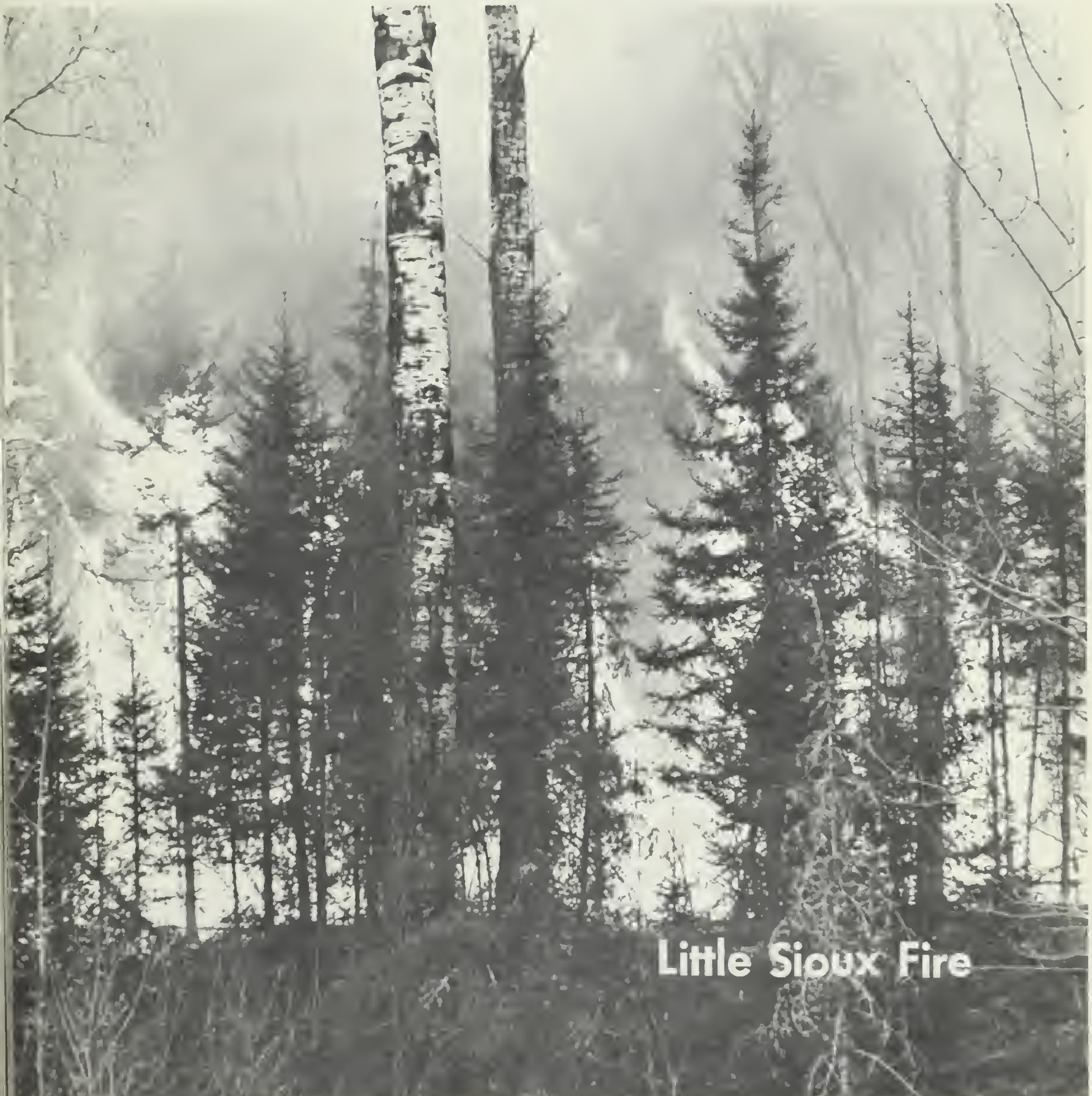

Little Sioux Fire

FIRE CONTROL NOTES

An international quarterly periodical devoted to forest fire control

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Cover—The Little Sioux Fire, Boundory Waters Canoe Area, Superior N.F., Minnesota, made 80 percent of its run on May 16, 1971. The fire consumed approximately 15,000 acres of balsam, spruce, jack pine, and aspen before it was controlled. Frost and snow helped speed mop-up on May 19th. (Photographed by Charles Curtis of the Duluth *News Tribune*.)

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PREVENTION

What Have You Done About It? Here's What Pennsylvania Did

E. F. McNamara

All fire protection agencies must work to place prevention in its rightful place as an equal partner with suppression. This is the only way that the protection program can keep up with increasing fire risks and hazards.

Advocate of a Strong Program

Over 99 percent of all wildfires in Pennsylvania are caused by people. Since the Commonwealth has 12 million people and 17 million acres of forest land, the justification and need for a strong program of fire prevention is apparent.

Pennsylvania has consistently been an advocate of a strong fire prevention program and began intensive educational activity in problem areas during the 1930's. When the Smokey Program began, the Keystone State welcomed Smokey and has continually promoted the program at a high level.

In recent years the Division of Forest Protection has felt the need for involving more people over a longer period of the year in fire prevention. Fire Prevention Days and Fire Prevention Weeks did not give the all-important impression that fire prevention is really a full-time responsibility.

During 1969 a plan for a massive, year-long, Statewide Wildfire Prevention Program was developed.

The secret to such a plan is to get as many people as possible interested in it. In late fall 1969 State Forester Cobb gave his full support to the plan. He in turn received the approval of Secretary Goddard, the head of the Penn. Department of Environmental Resources.

E. F. McNamara is chief of the Div. of Forest Protection, Bur. of Forest., Penn. Dep. Environmental Resourc.

Governor Participates

The kickoff for the year's program was the official signing of the "Make 1970 Wildfire Prevention Year" Proclamation by the Governor. The proclamation was issued in February 1970 and got good Statewide publicity. During the ceremonies in the Governor's Office the Governor became a Fire Warden and received a Smokey bronze relief shield (fig. 1). State Forester Cobb presented the Governor with a Smokey wrist watch.

Getting the Governor involved automatically involved all of the other Agencies of State government:

1. The Wildfire Prevention message was put on the biweekly salary check statements for 106,000 Commonwealth employees for 12 pay periods.
2. The message was carried in the 605,000 copies of the June issue of the Pennsylvania Liquor Control Board Price List.
3. 25,000 copies of an insert published in an issue of Pennsylvania Forests Magazine were purchased. A copy was sent to all Volunteer Fire Wardens (3,800), Volunteer Fire Companies (2,400), Railroads (400 copies) and interested organizations and individuals throughout the State (fig. 2).
4. Each car in the State Motor Pool (300) was equipped with a fresh Fire Prevention Litterbag each week.
5. A postage meter slug was used with the slogan "Make 1970 Wildfire Prevention Year" on the Department's postage machine.

In addition, all mail from the

Figure 1—Governor Shafer received Smokey wall plaque from Fire Protection Chief McNamara.

Division of Forest Protection carried the message on the outside of every envelope and also on the stationery used for correspondence. Many of the Districts followed this practice also.

USDA Cooperates

The Supervisor's Office on the Allegheny National Forest joined in the Program and also stamped official mail with the slogan.

During this same year, Pennsylvania purchased and distributed over 1½ million individual pieces of CFFP and allied educational materials and processed almost 20,000 individual requests for Junior Forest Ranger Kits.

Results Were Encouraging

What were the results of this massive Prevention effort? During 1970, 719 forest fires that burned 4,190 acres were recorded. This was the third lowest incidence of fires and second lowest area burned since 1913.

During 1969 there were 1,735 fires reported and 16,508 acres burned. This was an above average year for the State (table 1).

Since weather plays such a vital role in fire protection, a comparison of Fire Danger class and fire occurrence during 1969 and 1970 will provide some insight into the weather conditions during the two years.

Heavy snows over much of the State in 1970 contributed to a reduction in fire occurrence during March of 1970.

Difficult to Measure

The results of a Fire Prevention Program are difficult to measure. No satisfactory method of evaluating the many variables involved have yet been developed. There is, however, a

Table 1.—*Average Per Year Fire Statistics*

Period	No. of Fires	Area Burned	Av. Per Fire
1955-59[1]	983	28,832 acres	24.2 acres
1960-64	1,623	30,453 acres	18.7 acres
1965-69	1,334	12,167 acres	8.9 acres

[1] Lowest 5-year period in fire occurrence in Pennsylvania history. Fire incidence began upward trend in State in '60's. Similar trend noticed Nationwide.

Table 2.—*Comparison of fire danger and fire occurrence*

Month	1969 Days Class 3[1] or Above		1969 Forest Fires		1970 Days Class 3 or Above		1970 Forest Fires	
January	53		5		1		0	
February	38		11		34		6	
March	186		308		61		20	
April	198	452[2]	729	1429[2]	212	377[2]	379	606[2]
May	68		392		104		207	
June	12		41		3		19	
July	2		19		1		1	
August	5		16		4		16	
September	27		12		13		7	
October	120		170		28		11	
November	61	206[2]	19	202[2]	42	112[2]	34	64[2]
December	25		13		42		19	
		658		1631		489		670
Totals	795		1735		545		719	

[1] Total days of Fire Danger Class 3 units or above based on Spread Index at one or more of 14 Fire Danger Stations throughout the State. The maximum number for any one month would be 14 multiplied by days in month.

During 1969 there were 218 fires per 100 Class 3 day units.

During 1970 there were 132 fires per 100 Class 3 day units.

April 1970 was the only month during the two years when all days recorded a Class 3 situation at one or more stations.

[2] Days in normal fire danger periods.

definite reduction in fire occurrence when measured against Fire Danger Class (table 2).

We know that the time, effort, and investment have been worthwhile. Many unsolicited letters were received from Fire Chiefs and members of Volunteer Fire Companies complimenting us on the program and stating that grass fires were at the lowest point ever in their respective areas. One Fire Chief also credited our Prevention Program with a 30-pecent reduction in structural fires.

Community leaders from many of rural areas wrote or telephoned our offices to tell us how much they supported our Program.

The effects of the "Make 1970 Wildfire Prevention Year" will carry over into 1971 and future years. And our 1971 Program is in full swing.

What's Success?

The secret to a successful Fire Prevention Program is getting people involved. People do want to help–you must tell them what you want them to do.

You will find also that, while the primary objective of your program may be fire prevention, there are many other benefits helping the total conservation program. △

Figure 2—This reprint of a fire-prevention article was sent to various interested State groups.

Pieces of Paper Protect You: Specifications

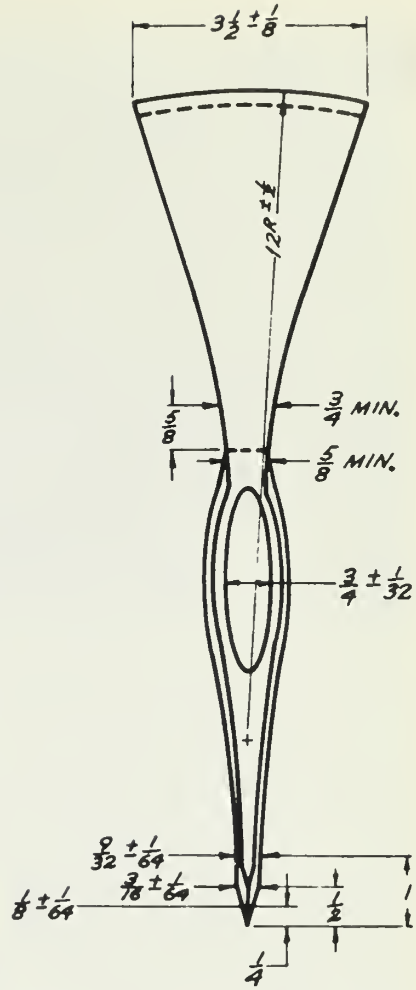
B. J. Graves

The Forest Service uses equipment designed specially for fire control operations.

A document called a specification defines for the manufacturer the acceptable standards for all this equipment. Standardization just for the sake of conformity, however, is not worthwhile and can do more harm than good. There have to be other reasons for a specification. These reasons, *all* of which must apply in any one instance, follow:

1. Other available specifications or standards are inadequate.
2. The item is going to be standardized Service wide, usually for the following reasons:
   a. Economy by central purchasing through the Federal Supply Service.
   b. Training simplification.
   c. Quality insurance.
   d. Interchangeability of parts or sub-assemblies.
3. The item covered will be purchased on a recurring basis, over a relatively long period of time. (Items that are purchased infrequently or over a short period of time should be covered by a bid specification.)

Forester B. J. Graves works with equipment and specifications in the Aeronautics and Equipment Branch of the W. O. Div. of Fire Control.



This schematic drawing of the head of the pulaski is taken from the pulaski specification.

Importance Has Grown

Started in the 1930's, when standards of design and performance were first formally documented, the Forest Service's Fire Control specifications now number about 100. Compared to the nearly 5,000 Federal Specifications and many more Military Specifications, Fire Control's are few. However, they do account for a large expenditure of Fire Control money — about $5,000,000 annually.

Specifications other than those of the Forest Service play an

important role in Forest Service specifications not only as procurement documents but also as references. The pulaski specification, for example, includes such applicable documents as Federal Specifications and Standards for handles, NN-H-93, and for test methods for metals, FED-STD-151. Military and civilian standards are used for pulaski testing, MIL-STD-105D and ASTM[1]-STDS for instance.

Developing a Specification

Equipment development centers at Missoula and San Dimas and the Beltsville Electronic Center prepare most Fire Control specifications; although, some specifications to be adopted Service-wide are prepared in Forest Service Regions. Once a project at one of these centers develops a piece of equipment to the point where a demand for purchasing it for Service-wide use is likely, a formal specification is prepared: Engineers, researchers, and other specialists provide the technical data, and a specification expert prepares the information formally as a specification.

Before final acceptance by the Service, however, the specification is subjected to a thorough review by GSA, manufacturers, Fire Control field representatives, and the Washington Office Division of Engineering. These reviewers often suggest changes in the document to improve the product or reduce its cost. The W.O. Division of Fire Control gives the final review and has the responsibility for accepting the specification. W.O. Fire Control also assigns a Service-wide number to it. For a new specification, an "interim number" is assigned. Interim status is indicated by "00" preceding the prime number, for example, 5100-0093.[2] The interim designation is in effect until the document has been used and proven sound. In the case of the number example given above, the permanent number would be 5100-93. The W.O. Division of Administrative Services is responsible for printing, distributing, and maintaining a supply of the specification.

The development center originating the specification retains custodial responsibility for it and keeps it updated.

Specifications Save Money

In 1968 the estimated cost of specification maintenance at the Missoula Center was $750 per document. This is much less than the annual average of $2,700 per document for other Federal specifications.

This expense, in any case, has an excellent cost-benefit ratio. GSA estimates that buying from a Federal procurement document, as opposed to buying brand-name-or-equal, saves the Government an average of $25,000 per year for the equipment each document represents. Almost 10 dollars are saved to every 1 spent.

Assurance Needed

The Forest Service requires assurance *after* the contract is awarded that the manufacturer is producing an item according to the specification. This is covered in the inspection and test section. In some cases, however, the Forest Service wants assurance that the manufacturer is capable of producing an item meeting all requirements *before* the contract is awarded. This type of assurance is determined by prequalification testing and is made when any *one* of the following conditions exists:

1. Testing after award of the contract would unduly delay delivery of the item.
2. Repetitive testing would be expensive (quality control).
3. The tests would require expensive or complicated testing equipment not readily available.
4. Performance results as well as technical requirements in the specification would determine acceptability of the item contracted for.

Prequalification testing is done at the development centers (see article on simulator, p. 7). Manufacturers submit samples of their product made according to a particular specification. These samples are tested, and all those meeting the specification are placed on a "qualified products" list. The manufacturer of a qualified product is then eligible to bid on a GSA contract.

Prequalification specifications are kept to a minimum since the testing is often time-consuming and can develop into a major job. Only 15 percent of the Forest Service specifications are of this type. Some of the more complicated prequalification testing is done on: Fire retardants, hose, fireline trenchers, portable pumps, and spark arresters.

People Are Needed, Too

The Fire Control specification program is dynamic. New specifications are written as equipment is developed; revisions are made to keep the document current; and those documents no longer needed are rescinded.

Specifications are as good as the information feedback from users of fire control equipment. Employee suggestions and equipment performance reports are vital to the success of the Forest Service specification program. △

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[1] American Society for Testing Metals.

[2] 93 is the prime number. 5100 is the function number; it means "Fire Control."

New Compact Simulator Provides New Versatility

Herman E. Ball

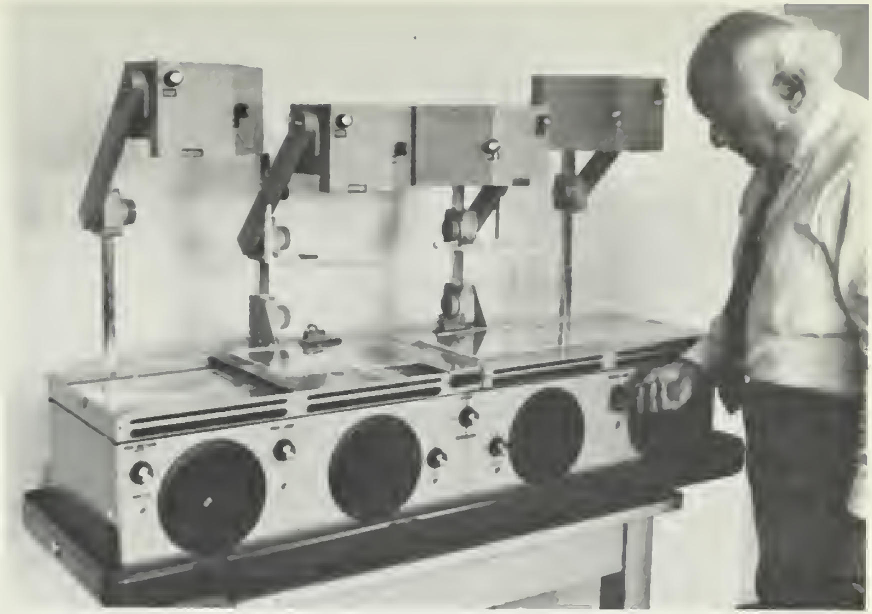


Figure 1—The new compact simulator set up and ready for action.

The new compact simulator is now a production model that will be delivered to 76 customers throughout the United States and Canada early this summer. This is the latest model in forest fire simulators (fig. 1). It culminates 3 years of research and development work aimed at providing field units with an inexpensive, highly portable, initial attack training simulator.

To begin with, an extensive survey was made of fire control people all over the country to determine what features were most wanted in a portable simulator. Results of the survey were used to develop and test a prototype simulator similar to the one discussed here. Specifications were drawn up and prequalification testing, made (see article on specifications, p. 5). After demonstrating the prototype to potential customers, a consolidated order was taken and a contract let with Scott Engineering Sciences of Pompano Beach, Fla., for 76 machines.

H. E. Ball is a forester at the Forest Service Electronic Center, Beltsville, Md.

Many Features

Its many features make the new compact simulator a very versatile machine that can handle a variety of training situations, yet it is simple enough for one man to operate. It employs the rear screen projection technique in which the operators are on one side of the screen and the trainees, on the other. This technique tolerates more light in the training area than do the front projection methods employed by some of the earlier simulators.

One of the outstanding features of this machine, from the operator's standpoint, is that the direction of art work on all working stages is directly coordinated with its appearance on the screen: forward and to the right on the working stage is up and to the right as the operator sees it on the screen. Adjustable and reversable discs are used to simulate smoke and fire motion. The motion can be projected in any direction and directional changes to simulate wind shifts are easily made during an exercise.

Two background scene projectors projecting identical scenes allow the operator to do art work during an exercise without distracting trainees. A dissolver makes the illumination transition between scene projectors so smooth, it is difficult to detect. Hose lays, fire lines, roads, helispots, etc. are clearly projected through an overlay on the background scene, and these can be manipulated in response to the trainee's actions. By means of a char plate located above the scene, fire can be gradually replaced with burned-over area. Another plate allows the operator to change the composition of smoke from light to dark and back.

Portability

The total weight of the unit in its aluminum, dust and moisture proof container is 176 pounds (fig. 2). It comes complete with extension cords, spare lamps, tool kit, and maintenance manual. It is easy to set up and take down, and it is packed well

Figure 2—The simulator packed up and ready to travel.

enough in its container to withstand the treatment a portable unit is normally exposed to.

Though the simulator is designed primarily for initial attack training, its use need not be limited to this. Complemented with the proper communications and sound equipment, it can be used for the more complex command-type fire problems. It may also be used in training for structural fires, timber sale layouts, avalanche control, road layouts, recreation planning, multiple use, aesthetic considerations, and watershed rehabilitation project planning. With a little imagination the compact simulator can be used in other areas where visual simulation is desirable.

The new compact simulator shown and discussed here includes only the optics and projection equipment used for visual simulation. The field survey mentioned earlier indicated such a variety of requirements in audio equipment that no attempt has been made to come up with a standard package. The selection of audio systems and other accessories has been left to individual tastes.

Here's Where To Write

A publication available from the Forest Service Electronics Center, Bldg. 419, ARC, Beltsville, Md. 20705, list recommended components with prices and sources for an audio system, a screen, and other accessories that can be used with the new compact simulator. △

Fires Burn Trees . . . And Other Things

From a publication of the Int. Assn. of Fire Chiefs

Fires set a new record in 1970 in the United States with losses reaching an all time high of $2,263,918,000.

This was a 16-percent increase over the 1969 loss of $1,952,022,000 and was the first time in history that fire losses exceeded $2 billion for any year.

Fire losses in December alone were $224,025,000, up more than 41 percent from the November total of $158,486,000 and nearly 25-percent higher than the December 1969 loss of $179,430,000.

Included in the December 1970 total is the multi million-dollar fire loss at the Humble Oil refinery in Linden, N. J.

The estimated fire losses include an allowance for uninsured and unreported losses. . . . △

Smoke Dispersal Determines When to Burn

A system for regulating burning of logging slash based on smoke dispersal conditions was completed and placed into effect in 1969 by all fire control agencies in western Oregon and was continued in 1970. It gives foresters guidelines for slash burning based on weather conditions and the proximity to major population centers. The system was developed jointly by the Pacific Southwest Forest and Range Experiment Station and the Pacific Northwest Region of the Forest Service with the cooperation of the Oregon State Forestry Department, Oregon Forest Protection Association, Bureau of Land Management, and the Bureau of Indian Affairs.

Under this system unlimited burning is permitted when winds will carry the smoke directly away from the more heavily populated areas. If winds are variable or toward a designated "smoke sensitive" area, burning is limited by factors such as distance from the area, anticipated elevation of smoke layer, and the depth of air currents through which the smoke will mix.

The Oregon Department of Environmental Quality has entered into a Memorandum of Agreement with the above agencies to implement this cooperative slash smoke management plan to minimize slash smoke accumulation in designated areas of high population density. The Forest Service's Northern Region has initiated a similar system. △

Films To Fight Fires By

A new Forest Service training film, "Sector Boss," was distributed to field offices during 1970. The film places emphasis on the sector boss as the key man in the middle of the line overhead organization. The film's purpose is to strengthen leadership, tactical performance, and cost consciousness of overhead engaged in fire suppression. The 16mm. color and sound movie runs approximately 30 minutes.

Another fire training film, "Nine Out of Ten", was released about April 1971. This 30-minute film shows 10 essentials for improving fire prevention in action and is aimed at improving the prevention performance of field forces.

"May Day" is the latest fire training film produced by the Northeastern State Foresters in cooperation with the USDA Forest Service. Its theme is the efficient use of heavy equipment on fires, and it is designed to motivate and inform. This training package includes automated slide-tapes providing specific training on selected heavy equipment.

How Do You Get a Film?

Prints of these films may be obtained for free loan from any Forest Service Regional Office and from many cooperating State film libraries. For additional information on borrowing or purchasing prints, write to USDA Office of Information, Motion Picture Service, Washington D.C. 20250. △

Region 3 word and symbol fire prevention poster, "Use Your Ashtray".

SYMBOLS for Prevention Signs

Franklin O. Carroll

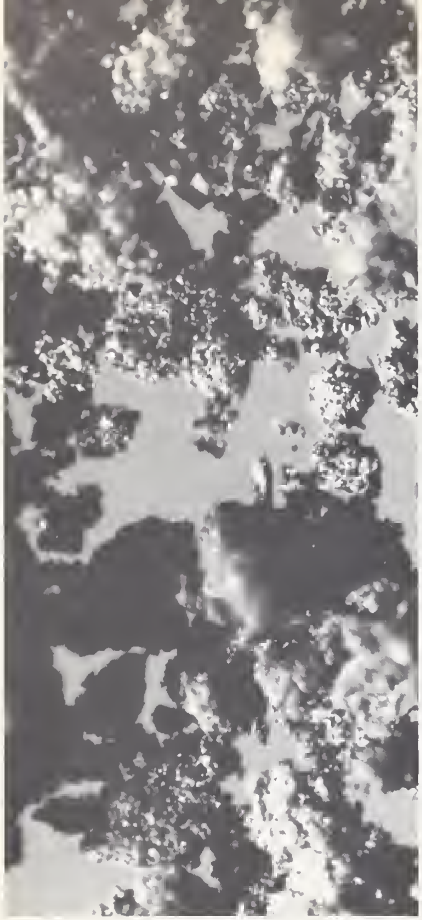
Symbols are supplementing some worded fire prevention posters in Region 3. For the past year, the region has been using newly-developed fire prevention posters containing both words and symbols. Symbols may soon replace some of those posters entirely.

The symbol poster has two major advantages. It can be made large enough to be visible along high-speed roads, and the symbol carries a complete fire prevention message.

Forester, Div. of Fire Control, Region 3, Albuquerque, N.M.

The principal disadvantage is the need to teach the public the meaning of each symbol. We are in the public education stage now, using the combination word-symbol posters.

Because the people in Region 3 are constantly exposed to the word-symbol posters, they will understand symbol-only posters much sooner than people from outside the Region. For this reason, roads supporting local traffic will have symbol-only posters by 1972, while major roads and highways will require word-symbol posters until the symbols are recognized nationwide. △



Exhaust Particles

How Many Fires Do They Start?

J. L. Hickman

This article is excerpted from Floyd D. Maxwell and Charles Mohler's "Interim Report No. 1. Exhaust Particle Ignition Characteristics." The report deals mainly with plans for study.

For many years firefighters and research scientists have suspected that many fires are ignited by exhaust particles from locomotives. However, only a few such fires have been positively identified.

In an effort to find out if many fires are started by exhaust particles, the San Dimas Equipment Development Center and the Pacific Southwest Forest and Range Experiment Station, Riverside, Calif., are jointly conducting a project to study ignition characteristics of exhaust particles.

Ignition Characteristics: How Particles Burn

Knowledge of where and how an exhaust particle is formed will be essential to be able to predict its ignition characteristics. In addition, other characteristics of the particle will have to be defined: How it is ejected from the engine, how it contacts the forest fuel, and how the state of the forest fuel affects it.

Areas of Study

There are two main areas of research that will probably be the most difficult. One is concerned with how these particles are formed and what they are made of. The other is concerned with the aerodynamics and thermo-chemical processes of the particles after they leave the exhaust pipe.

Immediate study in this project will be concentrated in:

Collecting controlled particle samples and beginning the testing of them; 1. continuing chemical analyses of the particles, and 2. determining particle trajectories and continuing their analysis.

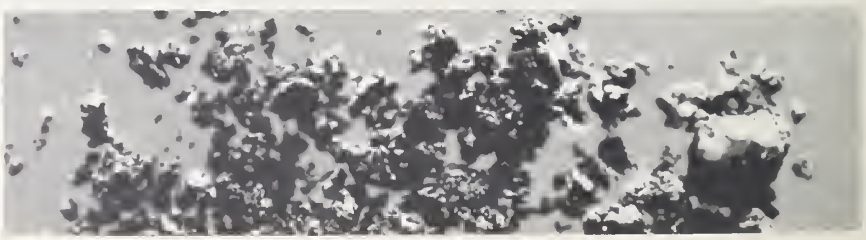
Equipment has been developed to simulate exhaust emissions. It can produce exhaust particles up to ½-inch dimensions and can operate at temperatures up to 1800° F. This equipment will be used to demonstrate possible particle trajectories, to demonstrate the hazardous effects of combinations of particles and forest fuel conditions, and to help establish conditions for further study.

Some Work Has Been Done

Maxwell and Mohler have revealed two factors that appear to vary significantly from previous assumptions—the amount of liquid diesel fuel contained in the particles and the behavior of that fuel in some particles. Laboratory experiments revealed liquid fuel content as high as 30 percent of the total weight of some samples. Boiling of the liquids occurred at approximately 375° F. and ignition occurred at approximately 750° F., much less than the temperature of the exhaust. Flaming combustion continued for more than 30 seconds after ignition in a number of cases. Therefore, it would appear that a particle can undergo cycles of flaming and glowing combustion even longer than 30 seconds after leaving the engine as part of the exhaust. The authors have yet to determine what condition forest fuels must be in to be ignited.

A Beginning

The questions have been asked, methods of study have been determined, and work has begun. Maxwell and Mohler will report on the progress of this study in the future. △



Forester J. L. Hickman works with equipment development in the Aeronautics and Equipment Branch of W. O. Div. of Fire Control.

Simulator Training Is Refined In Florida

Florida Division of Forestry, Fire Control Bureau

The first forest fire simulators were constructed for the Forest Service, and, perhaps because of severe mountain fire problems in the National Forests, most early simulation dealt with the handling of masses of men and overall fire strategy. In the fire-plagued South, however, the emphasis does not necessarily have to be on major fires. On any major fire there is usually an abundance of skilled, experienced supervision. One of the big training needs in the South is to improve the inexperienced ranger in his initial attack efforts on the other 95 percent of the fires. These same tactics are applicable to a segment of a project fire.

Initial Attack Emphasized

Florida has been concentrating on initial attack training for several years in an attempt to cope with a turnover problem within firefighter ranks. In simulations, some typical items were stressed: selecting the proper apprach to the fire, scouting the fire, packing equipment in safe places, calling for help early when appropriate, and selecting a suppression tactic appropriate to the occasion. This last item gave us a lot of trouble.

We now believe that a solution is in sight. And like most worthwhile things, the answer is no single key or breakthrough but several things adding up to a new answer.

We decided to compile the Florida Division of Forestry's "Suppression Papers." This series of papers was begun in 1968 in an effort to collect and assemble all that was currently known about suppressing wildfires in the State of Florida. These papers were written by some of our most experienced and succcessful firefighters. These men set up fire situations containing varied inputs on weather, fuel, and fire behavior. The "Suppression Papers" are the result of the work of these men and represent their average answers of appropriate tactics.

Two Important Considerations

Two important considerations were recognized. First, the proper tactic depended largely on spotting (fig. 1) which was directly related to (a) relative humidity, (b) wind velocity, and (c) buildup. Secondly, we realized that for this purpose a "fuel type" was not a botanical feature but was only how the fire burned. In this concept, a pine plantation might be either a grass fire or a dense pine fire depending on what was happening. Likewise, a turkey oak scrub fire could be a grass fire or a blowy-leaf fire by our definitions.

We then made up several specific tactical charts (fig. 2). A set of rough charts was field tested on 180 fires during the winter of 1969-70 and found to be 66-pecent correct the first time. These charts will be refined in 1970-71.

How the Problem Is Played

In our system, the student in the simulator looks at the customary aerial or panoramic view but, at the same time, sees a second, close-up projection of the fuel type involved in the corner of the screen (fig. 3). Weather conditions are stated and the umpire has matching tactical charts from the "Sup-

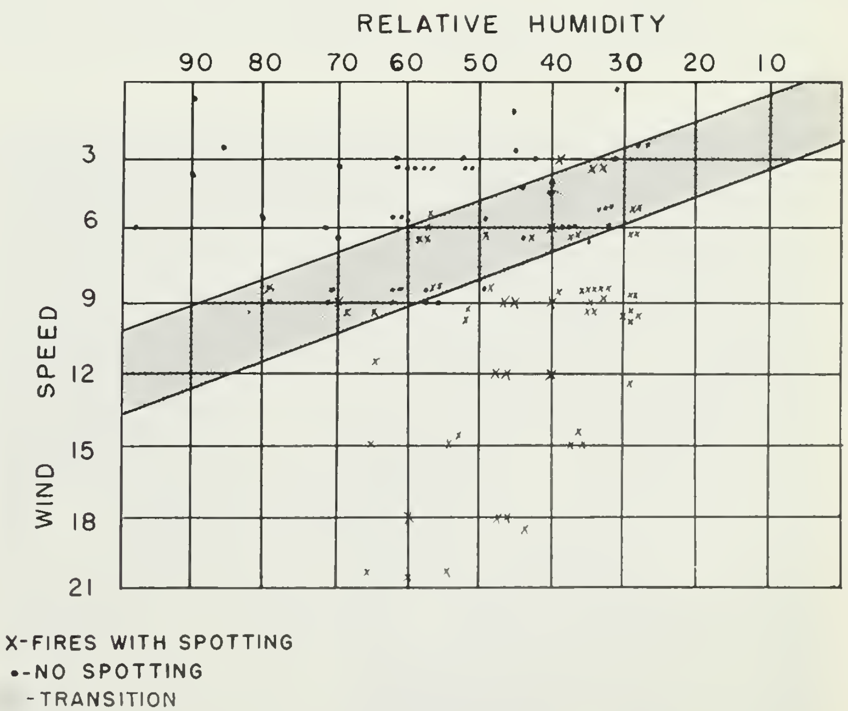


Figure 1—Spotting of wildfires in Florida as a function of windspeed and relative humidity.

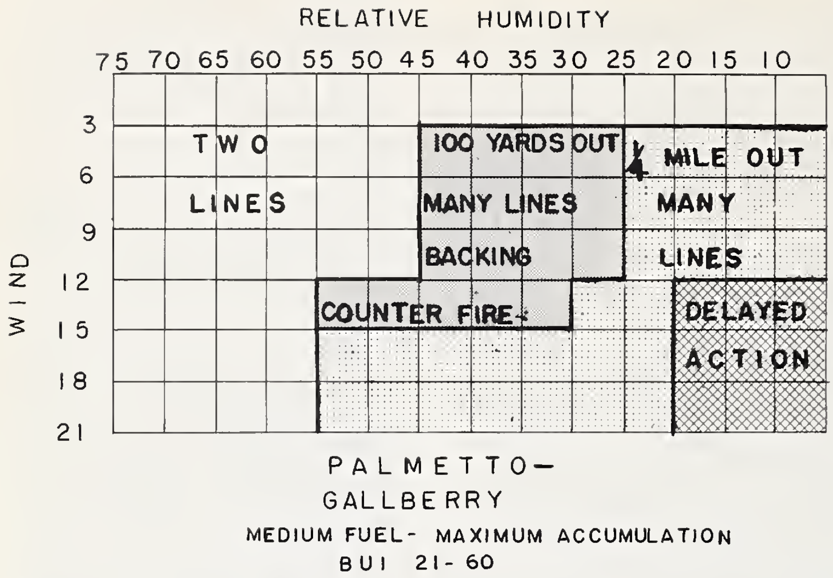


Figure 2—This is a tactical chart. It shows fire suppression activity based upon windspeed, relative humidity, and fuel type and condition.

pression Papers" in his hand. As soon as the weather conditions are stated, all role-players immediately recognize the situation as either a Category A (no spotting), Category B (short spotting), or Category C (long spotting), and the problem is played accordingly.

Overly conservative students' responses are criticized for wasting timber and time. Such inadequate tactics usually result in the fire escaping across control lines. Reasonable responses meet with success.

Problems often arise when simulators are sent on the road without Division supervision. There is a regrettable tendency on the part of some simulator operators to "put down" the trainee.

Fight Fires by the Book

The Florida Division of Forestry hopes to print a manual of standard tactics for specific fuel types and weather conditions in Florida, complete with color photographs of fuels which have been typed according to fire behavior. Included in the manual will be problem formats and guides for simulation. Fighting fire "by the book" is not as far off as it has been. △

Figure 3—Student viewing customary panoramic view of the fire location, showing barriers and forest types. The new, second view, in the lower left corner, shows the fuel type involved in the problem.

You Can Measure Salt Content Of Retardants

The effectiveness of long term fire retardants increases with the concentration of the active fire-inhibiting salt. With an increased number of in line types of mixing operations in service, it becomes very important to have quality control at each retardant base to assure maximum retardant effectiveness. Simple field procedures and calibration curves for determining the salt content of retardant solutions now in use have been developed at the Northern Forest Fire Laboratory, Missoula, Mont. You can get research notes describing these procedures by writing:

Intermountain Forest and Range Experiment Station
Northern Forest Fire Laboratory
Drawer 7
Missoula, Mont. 59801

Field First Aid Station

Richard L. Marsalis and

Ray G. Beasley

Field first aid station, note first aid symbol on tent lines for easy identification from the air.

The standard first aid kits are not designed for treating the large numbers of people who may need first aid in natural disasters, civil disorders, or on Class D and E wildfires.

The largest kit available, providing materials to treat about 30 people, is mainly useful for treating cuts and burns but not many other common ailments such as upset stomach, flu, bee stings, poison oak, and colds. Because of these limitations, firefighters have often been transported long distances to be treated by a physician, when the ailment might have been corrected at the work site had the proper first aid supplies been available.

Inconvenience and Costs Evident

The costs and inconvenience of inadequate first aid were shown in Region 1 during the severe 1967 fire season. From August 12 through September 12, there were 342 injuries. Of these, about 30 percent, 101 individuals, could have been treated with first aid. Since proper medication and supplies were not on hand, all these cases were sent to a physician at considerable expense in medical fees, lost time, and administrative costs.

In 1968 this Center was given the assignment to develop a first aid station for treating large numbers of men in the field. Station design and selection of supplies was based on information provided by various Regions, analysis of injury records, and consultation with a Department of Agriculture physician, Dr. Lee Buchanan. The U.S. Army Medical Center, Fort Sam Houston, Tex.; U.S. Army Medical R&D Center, Fort Totton, N. J.; Department of HEW; and Office of Civil Defense also contributed to the project.

While the station developed will mainly be used by Fire Control, requirements of other users were also considered. For example, the tent package may not be necessary for some fire camps, but would be a necessity if the station were used in Civil Defense and natural disasters. One of the main objectives of the project was to provide a complete first aid outfit ready to go at a moment's notice.

The Prototype

A prototype station was field tested in 1969 and 1970 in Regions 1, 2, 4, and 6. Test results indicated use of the station could effect considerable savings. For example, the station was used for 13 days on a 500-man fire in Region 2. An average of 21 men were treated each day, for a total of 273. Six of these men were sent to a physician for additional treatment.

At least 98 other men would have been sent to a physician had the first aid station not been available. Treating these 98 additional men would have cost about \$450 each, for a total of nearly \$45,000. Total cost of the station and its operation was estimated to be about \$2,500.

Furthermore, many men were spared the wait for transportation and medical care.

Field first aid station, side flaps up.

R. L. Marsalis is a forester and R. G. Beasley, an equipment specialist. Both are at the Equipment Development Center, Missoula, Mont.

The first aid station consists of six separate units weighing a total of 500 lbs. The station is designed and equipped so the emergency medical technicians are self-sufficient and require only food from the fire camp. The outfit will fit in a station wagon, or it can be delivered by helicopter or parachute. Medication and bandages are packaged in waterproof, dustproof containers. Once a location has been selected, two men can have the station operational in about 1 hour. A brief description of the units is as follows:

Unit 1: Medical Supplies—Medication, dressings, and instruments for first aid treatment of minor injuries, stomach disorders, colds, flu, bee stings, and so on. Two emergency medical aid manuals are supplied.

Unit 2: Utility Pack—Tools and equipment for maintaining the station, including waterbag, lanterns, flashlights, tool kit, and so on. Unit 2 also includes a special emergency kit for treating patients who may have to be taken a long distance from the station.

Unit 3: Tables—Two folding field tables.

Unit 4: Litter Set—Restraints, blankets, and two litters.

Unit 5: Tentage—One 10- by 12-foot wall tent, complete with aluminum poles, stakes, and removable floor.

Unit 6: Supplemental Medical Supplies—Medication, dressings, and supplies most likely to be exhausted when the station is operated for a week or more in a 500- to 1,000-man camp.

Who Runs It?

One emergency medical technician can serve for a 300-man camp effectively, two technicians for 300 to 1,000 men. The technicians should have training well beyond advanced first aid as taught by the Red Cross. Ex-military corpsmen, combat medics, and medical technicians make excellent workers.

If men so trained are not available, the station should be manned by men who have completed a course in emergency medical care offered throughout the United States by the American Academy of Orthopedic Surgeons. This course is 3 to 4 days long and is open to all who hold an advanced Red Cross first aid card.

The field first aid station will be furnished as a complete outfit. Units will not be sold piecemeal. However, all items will be available to restock stations as supplies are depleted. In an emergency, most medications and dressings can be purchased from a local medical supply house or a large drugstore. However, the cost will be considerably higher.

All medicines are specified by both generic name and a common brand name. None of the medications must be refrigerated or handled under Federal narcotics laws. Storage life of most items is at least 2 years.

How to Get One

Region 1 Division of Administrative Services will handle all orders, assemble the stations, and supply individual items for restocking. The first aid stations will be available about July 1971 at an estimated cost of $895 plus shipping and handling charges.

Inquiries should be directed to: USDA Forest Service, Division of Administrative Services, Missoula, Mont. 59801. Users outside the Forest Service who want to provide similar aid stations, can secure assembly instructions and packing lists from the USDA Forest Service, Equipment Development Center, Drawer G, Fort Missoula, Missoula, Mont. 59801. △

These Boys Do A Man-sized Job

Since the summer of 1960, boys from the Nevada Youth Training Center, a juvenile detention home, at Elko, Nev., have fought range fires in northern Nevada. In 1966 the fire crew picked as their symbol the falcon and became officially known as the "NYTC FALCON FIRE CREW." Through agreement, NYTC wards have been trained, equipped, and paid by the Nevada Division of Forestry as a professional firefighting force.

Because of high turnover, training must be continuous. Once a boy is accepted and placed on the fire roster he is given rugged physical training 1 hour a day, 5 days a week, throughout the fire season. The size of the work force varies from 30 to 40 boys organized into 10-man crews.

NYTC crews are used mostly for initial attack and follow-up on private land fires in Elko county, but in recent years they have been used extensively by Federal agencies. During the summers of 1965 and 1966 they assisted the BLM and Forest Service on 34 fires. △

Progress Sparks Remote-Sensing Seminars

Nationwide demonstrations of the latest techniques in airborne detection and mapping of forest fires were given in May and June by Forest Service scientists.

Seminar Series

A series of fire research seminars was held at the three forest fire laboratories — Macon, Ga., May 4-6; Riverside, Calif., May 25-27; and Missoula, Mont., June 1-3. The seminars demonstrated remote-sensing devices and techniques to more than 100 fire control specialists from throughout the United States and Canada.

The seminars were made possible through outstanding progress in the development of remote-sensing systems at the Northern Forest Fire Laboratory at Missoula. An instructor team of specialists from the Fire Scan and Skyfire research projects explained and demonstrated techniques and equipment for rapid and precise locating of small fires, mapping details of large fires, and tracking and measuring lightning storms and lightning discharges. A Canadian fire scientist, who has been participating in the program, was an instructor in operations research methods for forest fire detection.

Chief Cliff Commented

"We believe," stated Chief Cliff before the seminars began, "that the technology stemming from this research has a great potential for aiding in the solution of critical forest fire problems and in reducing the severe fire losses experienced recently in several forest regions. The seminars also will facilitate application of new methods now ready and will provide fire control managers with the needed background for use of advanced aerospace fire intelligence technology expected to result from Forest Service fire research programs." △

This airborne fire spotter can be mounted easily on any light aircraft.

INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U. S. Department of Agriculture, Washington, D. C. 20250. Articles should be typed in duplicate and double spaced, with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and organization.

Authors are encouraged to include illustrations with their copy. Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints or India ink line drawings are acceptable. Captions for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the caption separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the page proportions in mind and lettered to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands; don't use paper clips.

Any length article, up to 3,000 words, is welcome. Use any available editorial assistance; have a friend read your article. We will provide rewrite assistance and final review.

What do we want? Articles about communications, equipment and supplies, chemicals, fuel modification, prevention, suppression, training, and weather △

U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

OFFICIAL BUSINESS

POSTAGE & FEES PAID
United States Department of Agriculture

Smokey Reports

Public Exposure To Smokey Reaches All Time High

Public exposure to Smokey Bear and his forest fire prevention message reached an all time high during 1970. The Advertising Council, Inc., sponsor of the Smokey Bear program, reported a dollar value of $27,645,539 in traceable public service time and space in the United States. Network radio and newspapers represented the principal gains in exposure.

Search Is on For Smokey Successor

The Forest Service has begun the search for a successor to the living Smokey Bear, who celebrated his 21st birthday last spring. Smokey has resided at the National Zoo in Washington, D. C., since his rescue from a forest fire in the Lincoln National Forest of New Mexico. Ideally, Smokey's heir will be a brown-phase American black bear cub, with "wildfire-related experience," though the cub doesn't need to have been injured as Smokey was.

"Vanishing American" Adapted For Canada

The "Vanishing American," a Smokey Bear television spot released in 1969, has taken on an international flavor. This dramatic "commercial" has the camera sweeping up a tall pine tree to sound effects of 100 years of history. With the help of Foote, Cone, and Belding Advertising Agency's Toronto office, this spot announcement was fitted with a new sound track featuring Canadian historical events. The "Vanishing Canadian" was released in the spring of 1970. △

FIRE CONTROL NOTES

SPRING 1971 ● VOL. 32, NO. 2
U.S. DEPARTMENT OF AGRICULTURE ● FOREST SERVICE

FIRE CONTROL NOTES

An international quarterly periodical devoted to forest fire control

CONTENTS

COVER.—The heroism of dedicated men who risked their lives last summer to fight a forest fire in the state of Washington was spotlighted in "Wildfire!," a "GE Monogram Series" on NBC-TV. The MGM documentary graphically depicted the story of 8,550 firefighters who battled one of the worst fire disasters in the history of the Pacific Northwest. GE plans to air "Wildfire!" again on a national network later this year. (Sketch, courtesy MGM Television, doesn't depict FS safety practices.)

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WILDFIRE!

This story is taken from MGM Television publicity releases about the program Wildfire!, shown on NBC-TV February 5, 1971.

MGM documentary producer-director Jeff Myrow had been keeping a crack film crew at the ready mark for months, waiting for the Forest Service to alert him when a big blaze appeared in the making. The call finally came on August 24, 1970, from the Portland, Ore., regional office.

Myrow's original plan for "Wildfire!" had been to: "document a single forest fire as thoroughly as we could. Our purpose was to go in depth on individuals—the fire boss, the line boss, and some of the inter-regional fire fighting crews, the men that spend all summer fighting major forest fires."

That was before anyone knew that Myrow's "single" fire would multiply into three major holocausts. Myrow changed his plans:

"The story that we are going to do has gotten larger than a single base camp or a single fire boss," he noted at the time. "This fire has grown so large and become of such historical precedent in terms of size, acreage, numbers of men involved, and money being spent, that we are now keying on the major events each day wherever they take place [see figure]. The story that is happening here is monumental, and we feel an obligation to cover it in its fullest form. . . ."

8,550 FIREFIGHTERS

These firefighters were part of the continuing war against forest fires into the middle of which the MGM documentary film crew fell.

Like the firefighters, they slept little and moved fast. They carried their 30- to 50-pound gear up mountainsides, squeezed it into the helicopters carrying firefighters to the lines, and balanced it on the back of four-wheel-drive vehicles bumping down dusty, smoke-covered trails.

They fastened their cameras to the wings and undersides of B-2's, B-17's and other planes "bombing" with chemical fire retardents, and followed every move and action of fire bosses, line bosses, and individual firefighters.

Before the end of their assignment, the 27 cameramen, soundmen, and assistant cameramen had recorded on some 80,000 feet of film an inferno that cost $13 million to suppress and destroyed approximately 12 million trees on 118,000 acres—enough board feet of lumber to build 10,000 homes △

Figure.—MGM producer Jeff Myrow (far right) observes a group of professional firefighters plot strategy during last summer's devastating forest fires.

Background, Philosophy, Implementation—
National Fire Danger Rating System

John E. Deeming
and
James W. Lancaster[1]

After introduction of a partially-developed National Fire Danger Rating System (NFDR) in 1964 and subsequent analyses, the present research work unit was established at Fort Collins, Colo. in March 1968.

Full development of the NFDR System could proceed only after a thorough review of the work done as of 1968 and the subsequent establishment of guidelines for the future. These guidelines are now the philosophy of the NFDR. They are presented here, together with an up-to-date status report of the NFDR System which features three indexes for planning (occurrence, burning, and fire load indexes) and three components which rate the basic aspects of fire behavior (ignition, rate of spread, and energy release).

NFDR HISTORY

The need for wildfire danger rating on a national basis was recognized as early as 1940 at a fire control conference called by the Forest Service at Ogden, Utah. A committee report made two recommendations: (1) a relative fire danger rating system should be developed incorporating the factors that govern fuel moisture, and (2) the system developed should be applicable nationally.

It was not until 1958 that a joint committee composed of fire research and fire control personnel of the Forest Service started a danger rating development program. In June, 1958, the Washington Office, Division of Fire Research, organized the project, and a year later, full-time work was begun.

By 1961 the basic structure for a four-phase rating system had been outlined, and the first phase was ready for field testing. This was the *spread phase,* with which most readers are probably familiar. It provided two indexes which predicted the relative forward spread of a fire—one for fires burning in a relatively closed environment in timber and the other for fires in the open in fine fuels. A third index, the buildup index, which was incorporated in the spread computations, was a number related to the cumulative drying of the 10-day timelag fuels.[2] The spread phase was field tested in 1962 and 1963. In 1964 the *National Fire Danger Rating System Handbook,* FSH 5109.11, was issued for field use.

Since the remaining phases, ignition, risk, and fuel energy, were not developed, a number of fire control organizations preferred to remain with the rating system being used.

There were at least eight rating systems in use across the country at that time. Early operational use of the spread phase resulted in local modifications, making it obvious that even that phase system was not uniformly applicable. By 1965, however, most fire control organizations in the United States were using

Weather stations like this provide all the information for fire danger ratings.

Make accurate weather and fuels observations . . . accurate ratings depend on you!

[1] The authors are associate forester and principal forester, respectively, at the Rocky Mountain Forest and Range Exp. Sta., USDA Forest Service, Fort Collins, Colo., maintained in cooperation with Colorado State Univ.

[2] In this instance, the timelag period was related to a cyclic environment in which the *average* equilibrium moisture content was about twice that attained under constant laboratory conditions of 80° F. and 20-percent relative humidity.

the spread phase modified to some degree.

In 1965 a research project headquartered at Seattle was established to provide a fresh look at the needs and requirements for a national system. The Seattle project canvassed most of the fire control agencies across the country, analyzed the requirements, and recommended the development of a National Fire Danger Rating System.

In March, 1968, the present National Fire Danger Rating Research Work Unit was established at Fort Collins. The objective was to have a comprehensive system ready for field trials by the summer of 1970. Because of the wholehearted cooperation of many fire scientists and others in the field, this goal was met. More extensive field trials during 1971 will help to check out and introduce the system. By 1972, the target date, it will be ready for adoption on an operational basis.

FIRE DANGER RATING PHILOSOPHY

Several major decisions regarding objectives and the direction which the Fort Collins Work Unit would take had to be made before a "philosophy" of fire danger rating could be developed:

1. A target date had to be established for getting a completed system ready for operational field use. It was the consensus of numerous fire researchers that a fire danger rating system superior to any in use at that time could be developed from available "state of the art" information.

2. The basic structure of the system would be designed so that new knowledge, such as better prediction equations and improved fuel inputs, could be incorporated readily. Such refinements would take the form of updated computer programs or new tables supplied to the users; the basic format and definitions would remain unchanged.

3. The system would not be introduced piecemeal but would be offered as a complete, comprehensive package.

4. The complete system would include a subjective evaluation of risk. The development of an objective method would be deferred until the more pressing problems, such as fuel moisture relationships, had been solved sufficiently to meet the needs of the system.

5. Ultimately, the system would be purely analytical, based on the physics of moisture exchange, heat transfer, etc. Some experimentation would be necessary to establish basic relationships, but the system would not be empirically or statistically based.

With the above decisions providing a basic framework within which the project would function, questions had to be answered such as: What size of fire should we deal with? What aspects of the control job should be rated?

After answering these questions, and others the following concepts were adopted as the underlying philosophy of the NFDR System:

1. The system would consider only the "initiating fire," a fire which is usually containable by available initial attack forces (not one which is erratic, with crowning or spotting).

2. The system would provide a measure of the potential job of containment, which in turn would be considered as being linearly related to the length of flames at the fire front. The concept of containment as opposed to extinguishment was basic, since it allowed the research scientists to consider only those fuels which contribute significant amounts of energy during combustion in the immediate flaming front of the fire.

3. The system would evaluate the "average bad" condition by a) measuring danger in the open, b) rating the day with early afternoon measurements, and c) selecting southern or western exposures for measurements. In other words, extrapolating fire danger values for local conditions would usually involve scaling the rating values down, not up.

4. The system would provide ratings which would be physically interpretable in terms of fire occurrence and behavior. Because these components could then be used alone or in combinations, the system would have the flexibility needed to deal with the entire spectrum of fire control planning and dispatch problems.

5. Ratings would be relative, not absolute. This means that the doubling of an index or component would indicate a potential doubling of the rated activity relative to what had previously been observed. Because of the many variables in the computation and our inexact understanding of the interrelationships, we still cannot predict exactly what will happen in a given situation.

FUEL CONSIDERATIONS

Project scientists have classified the dead fuels into 1-, 10-, and 100-hour timelag classes [3]

[3] Lancaster, James W. 1970. Timelag useful in fire danger rating. USDA Forest Serv., Fire Control Notes 31(3): 6-8, 10 p., illus.

according to how fast the moisture content of the individual fuel particle responds to precipitation and changes in relative humidity. Two classes of living fuels are also considered: grasses and other herbaceous plants, and foliage and twigs of woody plants. One-quarter inch was set as the upper size limit of living plant material which can be dessicated, killed, and consumed in the flaming front of the initiating fire.

In the past, fire danger rating systems considered the variability of fuels only to a very limited extent. The 1964 spread phase recognized only open and timbered types; the California Wildland System recognizes three: timber, brush, and grass. The NFDR System, through the fuel model concept, treats the fuel phase of the fire environment to a degree of exactness never before possible.

HYPOTHETICAL MODEL

The fuel model is a hypothetical fuel complex representing one or more cover types which have similar fuel properties. As of this writing, eight general models which represent cover types ranging from the tundra of Alaska to the pocosins of North Carolina have been constructed. Fuel models will make it possible to tailor our system to local fuel situations. In this way, danger rating values will be consistent with fire behavior, regardless of differences in fuels.

A mathematical expression for computing the forward rate of spread of a fire was developed at the Northern Forest Fire Laboratory. It is the basis for application of the fuel model concept. The mathematical model considers such fuel bed properties as (1) bulk density, depth, and composition by classes of living and dead fuel particles;

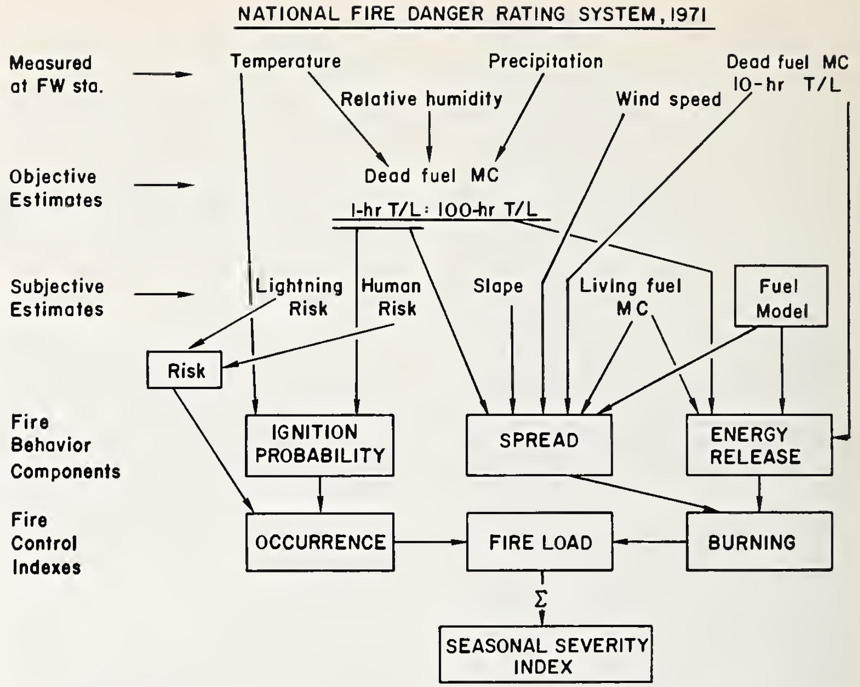

Figure 1.—Structure diagram of the National Fire Danger Rating System for the 1971 field trials.

and (2) fuel particle properties such as density, heat content, moisture content, geometry, and chemistry. With the exception of fuel moisture contents, average values for these fuel descriptors are assigned for cover types included in the fuel model. The moisture contents of the dead fuel components which are governed by local weather conditions are determined objectively by table lookup, computation, or by weighing fuel moisture sticks. The moisture contents of the living components are determined subjectively.

In the construction of fuel models, the NFDR group is working very closely with the fuel scientists who are participating in the Forest Service Fire Planning Task Force, so that the end products will fit together in a coordinated planning system. Terminology and definitions will be consistent.

STRUCTURE OF THE NFDR SYSTEM

The basic structure of the system (figure) yields three indexes designed for use in fire control planning.[4] Each has a scale of 0 to 100. They are defined as follows:

Occurrence Index–a number related to the potential fire incidence on a rating area. This index includes a risk factor which expresses the degree to which an area will be exposed to ignition sources. This index also contains the Ignition Probability Component, which defines the likelihood that fuels will ignite in the presence of an ignition source.

Burning Index–a number related to the potential total amount of effort needed to contain an average initiating fire on a rating area. The Spread and Energy Release Components make up the Burning Index. Indications of

[4] The NFDR System deals with fire occurrence, reflected in the O.I., and fire behavior, reflected in the B.I. and F.L.I. Nowhere does it reflect physical factors or production rates of crews and machinery.

how fast a fire is likely to spread and how intense it is likely to burn, when considered together, will give a relative measure of the potential difficulty of the containment job.

Fire Load Index–a number related to the potential total amount of effort required to contain all probable fires on a rating for a day. The difficulty of containing a single fire (Burning Index), multiplied by the probable number of fires (Occurrence Index), gives a measure of the potential fire containment job on the area for the day; this is the Fire Load Index.

In addition, the Seasonal Severity Index may be computed by summing the Fire Load Indexes recorded during a given period (see flow chart). The Seasonal Severity Index is useful as an administrative tool to estimate the potential fire control job in an area during a fire season or some other specified period.

The indexes should be particularly useful in daily preparadness planning. For dispatch and as an aid to prescribing action for the individual fire, three components incorporated in the indexes may be used separately because they are indicative of fire behavior: The Ignition Probability Component is an indicator of the potential for short-distance spotting; the Spread Component indicates the forward rate of spread of the headfire; and the Energy Release Component, a measure of the intensity of the fire front, indicates how hot it will burn and how close it can be worked.

SYSTEM READY FOR TRIALS

We have now made near-final changes in the system, and it is ready for the 1971 field trials. Tables have been redesigned, and operational instructions have been expanded. We will go into the field in 1971 with eight fuel models. Guidelines for helping field personnel select the proper fuel models for their areas have been written.

We are also working toward an objective system for selecting and delineating fire danger rating areas. For our purpose, a fire danger rating area is defined as a geographic unit where fuel and weather conditions produce reasonably uniform fire danger throughout. Because data from such areas will give a more accurate picture of fire conditions, we will realize a higher return for each dollar spent for fire danger rating.

An intimately related problem is a familiar one: How many fire danger stations are needed, how many can the user afford, and where should they be located to provide the best picture of fire danger. The idea that the most conveniently located station is the most desirable has always been detrimental to an accurate evaluation of fire danger.

We have only started on the evaluation of Risk, a major component of the Occurrence Index. Difficult as they are, the problems involved in the evalution of Lightning Risk appear readily solvable when compared to those posed in the determination of Man-caused Risk. Guidelines for subjectively determining risk inputs to the system will be available for the 1971 season. The far more desirable objective system, however, may not be completed for several years.

Fuel-moisture ANALOG

Much more promising is progress made in the development of an analog — an artificial fuel moisture stick — made of durable, inorganic, nondegradable materials for direct measurement of fuel moisture values. Tests have been run at the Northern Forest Fire Laboratory on several prototypes. A system which will eliminate weighing, and will instead electronically measure fuel temperature and the 1-, 10-, and 100-hour timelag fuel moistures, appears feasible. Electronic measurement is particularly desirable since it will make the analog adaptable to automatic weather observation systems with radio or land line telemetry. Another advantage is that analogs can accurately and easily evaluate all of the fuel moisture values which are now approximated through use of equations or tables constructed from these equations. The development and adoption of such a device would greatly simplify the work necessary to apply the NFDR System.

CURRENT KNOWLEDGE LIMITED

Current knowledge of moisture responses in litter and duff fuels is limited. We are temporarily assuming that litter and duff moisture relationships are similar to those for branch and other roundwood, with full knowledge that this is not entirely correct. We are now co-

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NFPA Reports:

Deaths Due to Fire Increase in 1970

Fire killed approximately 12,200 people in the United States during 1970, according to preliminary estimates by the National Fire Protection Association (NFPA) Fire Record Department. This is an increase of 100 over the previous year, and

see FIRE 1970, p. 14.

operating with scientists at the Southern Forest Fire Laboratory to determine these relationships. During the 1971 field trials the scheme for evaluating fuel moisture in the 100-hour timelag class will be based upon work completed for roundwood fuels only. This work demonstrated that, for roundwood, the duration of rainfall, rather than amount, governs moisture gains. Fire control men have long recognized this relationship, but it has not previously been subjected to detailed analysis.

The effectiveness of the new system is already being checked. The Fire Control Methods Project of the North Central Forest Experiment Station has accepted responsibility for this phase of the development. They will check the performance of the system against the records of more than 10,000 fires which occurred in Michigan, Minnesota, Wisconsin, Missouri, and Pennsylvania during the past 10 years. The evaluation will compare the performance of the new NFDR System against that of the 1964 version as a predictor of various measures of fire activity such as numbers of fires per day, man hours to control, final fire size, etc. The sensitivity of the various components and indexes to observed changes in the levels of fire activity from day to day will also be evaluated. △

INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate and double spaced, with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it, should appear the author's name, position, and organization.

Authors are encouraged to include illustrations with their copy. Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints or India ink line drawings are acceptable. Captions for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the caption separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the page proportions in mind and letered to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands; don't use paper clips.

Any length article, up to 3,000 words, is welcome. Use any available edittrial assistance; have a friend read your article. We will provide rewrite assistance and final review.

What do we want? Articles about communications, equipment and supplies, chemicals, fuel modification, prevention, suppression, training, and weather △

Truing A Grindstone

H. A. Janning[1]

If your grindstones received considerable use both during and after this past forest fire season, than the following method of truing them may be of value to you.

Temporarily affix a piece of 1-x-2-in. or similar slat across the frame of the grindstone as close to the face of the stone as possible without touching it. Fill the reservoir with water and allow the stone to turn for at least half an hour. The longer the stone turns in water the softer it becomes and the easier the truing operation will be.

Obtain a 3-ft. length of thin-walled steel pipe of approximately 1 to 2 in. in diameter and ensure that the end is cut square to its length. Vehicle exhaust pipe will do the job well.

Hold the pipe firmly on the slat with the square end towards the stone. Start at one edge of the stone and slowly revolve the pipe end across the face of the turning stone in a manner similar to using a lathe. At first the high portions of the stone will be shaved off. Repeat the process until the pipe and stone touch evenly all the way across the face for a full revolution. When this is accomplished the stone is true.

Drain the water from the reservoir and let the stone rotate for another half hour until dry. Remember, when a portion of a stone is allowed to sit in water it will soften and, when used, will wear unevenly. This is the most common cause of "out of round" grindstones. △

[1] Ranger supervisor, Prince George Forest District, British Columbia Forest Service.

No Smoke Needed

Robert F. Kruckeberg [1]

AT LAST!—a piece of equipment that can "see" fires we can't detect with our eyes.

Since most of you haven't seen one of our little "Fire Spotters," you probably are going to relate this statement to something you have read about or seen, such as a hand-held radiometer or one of the more elaborate fire mapper units now on the market. Don't do that—just read on about the simple, inexpensive, lightweight infrared (IR) line scanner that was built to help solve problems you have had for a long time.

"WHAT PROBLEMS?" YOU SAY!

You have all spent hours looking for fires that someone reported, either in a specific or general area and then when you got there the smoke was no longer visible and you couldn't find the fire. Maybe a few days or a week later the smoke shows up again and you go out and look but still can't find it. Finally, when conditions are right for burning, the fire takes off and burns a good sized chunk of country before you get it stopped.

Or, you have a big fire going and are worried about spotting out ahead of the fire or outside the fireline that is holding, but heavy smoke prevents you from

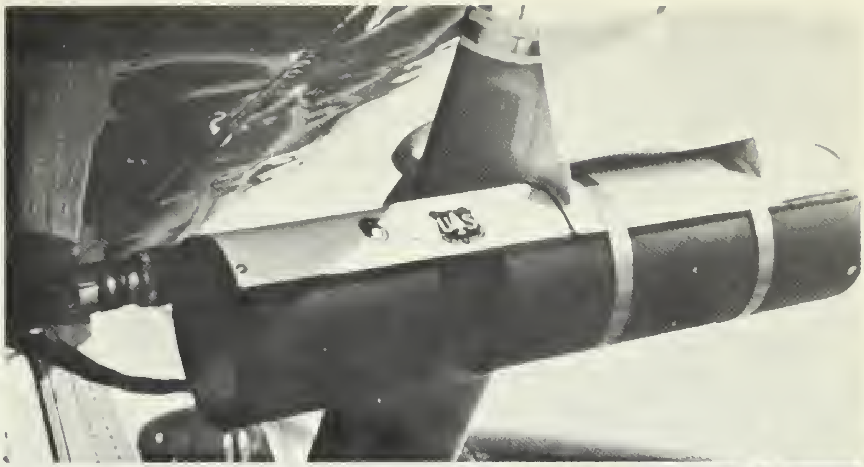


Figure 1.—Above, Spotter mounted on strut of Cessna 185; and below, control box inside aircraft.

finding spots until too late.

Or, the big fire is controlled, but you need to know where to send your mopup crews to do the most good so they won't wander around all day checking areas that are cold while other areas need attention. This is especially true where you have lots of unburned fuel inside the fireline.

These are the old problems—but what really prompted the experts here in Project Fire Scan to get into the "Fire Spotter" business was problem created by the project. Our big, high-flying infrared fire detection system was locating fires so small no one could find them.

We wanted this . . .

Searching for the device to solve this problem, we set up a list of criteria [2] :

1. The unit had to be able to detect 1-square-foot of hot material from 2,000 feet away. By hot we mean from 1,000° to 1,500°F.

2. It has to be relatively inexpensive—we felt if a unit cost over $2,000 no one would purchase it.

3. It has to be simple so operators could be trained easily.

4. It has to be small enough to mount on a light aircraft or helicopter.

5. It has to be reliable and require little maintenance.

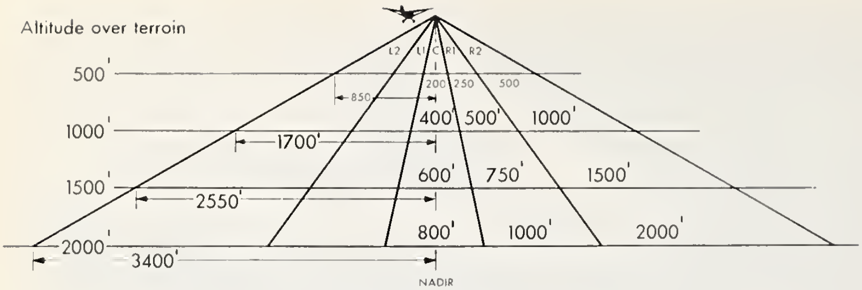
. . . and we got it

The result was the "Fire Spotter" shown in figures 1*A* and 1*B*—a line scanner complete with revolving mirror, infrared detector, control unit, and necessary electronics.

Here is the way it works:

[1] The author is currently research forester in Project Fire Scan, stationed at the Northern Forest Fire Laboratory, Missoula, Mont. Prior to this assignment he was fire staff officer on the Shoshone National Forest.

[2] If you are interested in more details on this equipment, its design, construction and theory, write for Forrest H. Madden's Research Note, "The Airborne Infrared Fire Spotter" (in preparation for publication), Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.



Total area scanned 120°.
Each light represents 24° scan angle.
Spotter must be horizontal for distances shown to be accurate

Figure 2.—Area scanned by spotter.

The revolving mirror scans the ground below the aircraft. The five lights on the control box each represent 24° of a 120° scan angle directly below the aircraft (fig. 2). If the R2 light goes on, and you are flying 2,000 feet over the ground, you know you have a hot target to your right, somewhere between ¼ and ½ mile away. At 500 feet over the terrain, that same light indicates that a target is only 350 to 850 feet off to your right.

We built 10 of the units last winter, and put them out for testing under actual field conditions this summer. Results show that we have a tool that works—one that will go a long way toward helping solve the problems mentioned. There may be other uses we haven't discovered yet.

Barnes Engineering Company of Stamford, Conn., is now marketing a unit similar to the ones we built. They have used our experience to produce a scanner that meets the criteria we set up, eliminating some of the maintenance problems but not the reflection and electrical interference problems. These units have been tested in the field, but delivery was too late to provide conclusive data this year. However, results look very good.

SOME OF ITS USES

We found intermittent smokes that weren't readily visible until pinpointed with the spotter. One logbook entry was typical:

> Lightning strike reported by lookout as smoke seen. Smokechasers did not find the fire. Spotter picked it up after second pass. Then we could see real thin smoke against the sun. Smokechasers put fire out.

We found fires that had no visible smoke at all, but these were usually ones that we already had a good location on. This was not always the case, as indicated by this logbook entry: "Bonneville Power R.O.W. clearing. No visible smoke. Ground crew located dozer pile with coals approximately 1 gallon in size."

Spot fires outside of firelines were located using a helicopter-mounted "spotter." Hot-spots inside the lines of both wildfires and controlled burns were usually readily visible to the unit mounted on a light plane.

SOME OF ITS BUGS

This "Fire Spotter" may not be the complete answer to your detection needs, and it may have problems in its application. We *did* have maintenance problems that were partly the result of a design feature. The scanner *can* "see" things that aren't fires but that still trigger the lights—such as sunlight reflections off water, aluminum roofs, and shiny surfaces. Noise from radio transmitters and aircraft electrical circuits *will* trigger the lights. The scanner may *not* "see" all fires—even ones that are putting up smoke.

The maintenance problems we had were somewhat anticipated and the commercial version of our "Fire Spotter" has been designed based upon our experience. The reflection and noise problems are going to be with

Figure 3.—Commercial spotter manufactured by Barnes Engineering Company.

us unless we want to eliminate one of the basic criteria—that of low cost. However, we can train operating personnel so that they understand what the unit can do and what its limitations are. The problem of not "seeing" *all* fires is one they will have to recognize and try to understand. If some object is physically between the heat source and the rotating mirror, such as the bole of a tree or a rock, there will not be any response. Sometimes this can be corrected by flying a different path or at a different altitude, but you may have to wait for a change in the condition of the fire, such as when it burns out from under the log or out the side of a snag.

PERSISTENCE PAYS

The key to the use of this equipment is persistence, as revealed in a logbook entry made by an observer who used the "Fire Spotter" on three occasions and found three fires in less than 1 hour. During the 20 minutes' scanner operation of one flight, the following was noted in the log: "Lightning strike reported by lookout. Smoke chasers could not find. Made five passes [before locating the] fire. No smoke. Smoke chasers went back and found fire in crotch of tree." This incident shows how a conscientious operator can make this scanner "work" for him.

BEST USE

Because of the narrow scan width, limited coverage and reflection problems, our experience to date indicates the best use is in confirming and pinpointing reported targets—not in flying a detection patrol.

Our 10 experimental units flew over 420 hours on light aircraft and helicopters. We have records of 26 fires they picked up which would not have been found until later, perhaps much later—and maybe too late. △

Shaded Fuel-Breaks: Fire Control and Timber Both Benefit

Ernest V. Andersen, Jr.[1]

In keeping with the Multiple Use concept of the Forest Service, shaded fuel-breaks integrate fire control needs with timber management of the forest.

FUEL BREAKS IN GENERAL

A fuel-break is defined as "a wide strip or block of land on which the native vegetation has been permanently modified so that fires burning into it can be more readily controlled. There may not be a preconstructed fireline within the fuel-break."[2]

In weighing desirability of constructing fuel-breaks, the land manager must consider Value Classes[3] of the area to be protected as well as the impact on all the resources, including the visual resource within the fuel-break itself. He must also weigh effectiveness and construction and maintenance costs of the planned fuel-break against the cost of fire protection alternatives. Once the decision that a fuel-break is desirable has been made, the manager must determine construction standards.[2]

Fuel-Break Frustration

As selective logging of conifer stands in California has progressed, it has become increasingly apparent that fire presuppression activity in that area must include selective fuel manipulation. Due to both the impracticability in some cases of physical disposal of the slash resulting from selective cutting and the costs related to physical disposal, or both, the concept of the shaded fuel-break has been developed.

Shaded Fuel-Breaks

The shaded fuel-break has many advantages in the timbered area of Northern California (and probably elsewhere) than a completely cleared strip or fireline as a presuppression activity. The area of a shaded fuel-break remains in production of timber, frequently increasing both quality and quantity, forage, and browse; visual qualities are maintained or even enhanced; erosion potential is low-

[1] Formerly district timber management officer, Hayfork District, Shasta-Trinity NF; now district ranger, Red River District, Nezperce NF.

[2] Report on the Duckwall Administrative Study, Stanislaus National Forest, Region 5, 1967.

[3] Forest Service Manual 5191.11, Amendment No. 135.

Figure 1.—Map showing Ice Cream Timber Sale location. Note how completed fuel-break will separate high-fire-risk area north of Hayfork from large undeveloped area north of the planned fuel-break.

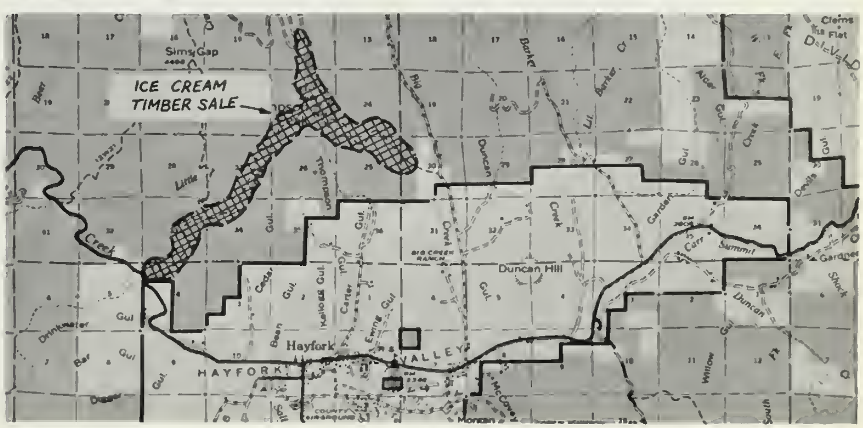


Figure 2.—A. Typical cross-section view of mixed conifer stand before treatment for a shaded fuel-break. B. Same stand after logging and slash treatment.

er, and maintenance costs are low.

TIMBER SALES

Timber sales can be used to accomplish much of the work needed to establish a shaded fuel-break system. Appropriated money may be needed in areas ineligible for cutting, in non-stocked areas, and in non-commercial areas. Nearly every commercial timber sale offers an opportunity to begin, improve, or maintain the fuel-break system.

The Ice Cream Sale

A timber sale called the Ice Cream Sale in central Trinity County, Calif., was begun by the Hayfork Ranger District of the Shasta-Trinity National Forest in 1970. The purpose of the sale is to remove selectively timber before creating a shaded fuel-break. The fuel-break in this location is high priority because it separates an area of high- and extreme - probability rates of spread and high resistance to control from an area of high man-caused fire risk (see fig. 1).

The entire sale was pre-marked. The required logging method is to use a mobile yarder on the part of the sale where slopes average 60 percent and slopes of 100 percent or more are common. In order to capitalize fully on this opportunity to develop a fuel-break, a 8 in. D.I.B. top utilization is required.

The stand is cut to separate tree crowns to a degree that crown fires burning into the completed fuel-break will drop to the ground (see fig. 2A. & B.). Yet, enough large trees and/or groups of smaller trees are left to shade the ground and to discourage the establishment and growth of understory vegetation. This balance in stocking is essential to keep maintenance costs at a minimum. It is expected that helitack crews, ground crews, all wheel drive tanker crews and air tankers would be able to control fires burning into the fuel-break.

In a sale like this, special timber sale contract requirements are necessary. Special care to protect the trees planned for leave must be exercised and intense slash clean up and disposal is also necessary. Well-planned cutting and slash disposal result in helispot sites where they are needed to meet hour control standards along the fuel break.

A collection from the purchaser is being made by the Forest Service to dispose of cull logs, tops, limbs, and other logging debris consistent with current policy. Cultural work in pre-commercial sized portions of the stand will require slash disposal measures appropriate to the primary purpose of the sale.

FLEXIBILITY FOR LAND MANAGERS

In other timber sale areas, the same measures are being taken on those portions of the sale where a fuel-break system is planned. Developing shaded fuel-breaks as an integral part of timber sales provides another option for land managers. To date, a total of 41 miles of shaded fuel-break cutting in the Shasta-Trinity has been included. △

Unimog Tanker-Plow Unit Cuts a "Wide Swath" In Firefighting

Richard L. Sassaman

In the summer of 1967, the Elk State Forest District acquired one of two Unimog 406's purchased by the Department of Forests and Waters for fire suppression. The Unimog was chosen for its capabilities of being both an off-the-road and an on-the-road vehicle (see fig.).

Upon receiving this unit, elaborate steps to insure driver safety as well as vehicle protection for off-the-road travel were taken. A protective frame-work was fabricated out of 6-in. channel iron to surround the cab, including a special grille guard. To protect the windshield, a 2-x-2 in. chain link fence was secured to the frame. This screen can quickly be removed when the vehicle is to be used on the highway for extended periods of time. Special shields were fabricated out of steel plate to protect the radiator as well as the fuel tank, air reservoir, battery, and roof of the vehicle. Two lights are mounted beneath the cab cover to aid in night work. The cab is equipped with 4-inch aircraft safety belts as well as aircraft shoulder harness, to help insure driver safety.

The unit is equipped with a 150-gal. fiberglass tank which has been permanently mounted within a steel plate shell. By means of a rather sophisticated plumbing system, the operator can draft either from an external source to fill the tank, or from the tank in order to use the live reel equipped with 150 ft. of $\frac{3}{4}$-in. hose. The operation is simple for the operator since all valves are readily accessible.

The Pacific Model "BE" pump is compact enough to permit its being placed partially under the protective shell which covers the tank. The pump can be started by the operator as he stands on the ground at the valve panel. Included with this use is a complement of spare parts and tools required to make minor repairs to the pump when in the field.

FIRE PLOW MOUNTED

After months of planning, the Unimog was taken to the Michigan Forest Fire Experiment Station in Roscommon, Mich., where it was outfitted with a hydraulically controlled, double-bottom fire plow. This plow has been designed and developed for use with four-wheel-drive trucks by the Michigan Department of Natural Resources, Forest Fire Experimental Station.

In mounting this plow to the Unimog, several modifications had to be made. The frame had to be extended to permit proper mounting of the parallel floating hitch. A complete hydraulic system was also designed and incorporated into the unit to handle the hitch and plow.

The hitch is unique in that it floats parallel to the ground permitting the plow to follow the contour as it trails the Unimog. This feature is quite desirable in that the plowed line is relatively free of "skips", requiring very little, if any, followup handwork.

A 3-in. flange welded to the 18-inch coulter, approximately $4\frac{1}{2}$ in. from the cutting edge, acts as a depth gauge and keeps the plow from cutting deeper than $4\frac{1}{2}$ in.

UNIT USED

Under ideal conditions the plow can be operated in fourth gear with moderate success;

Figure.—The Unimog 406, fully equipped, with plow in half-raised position.

[1] Forest technician, Pennsylvania Bureau of Forestry, Department of Environmental Resources.

however, second or third gear does a better job. If the unit is operated at too slow a speed, the turf falls back into the furrow since there is not enough speed to roll it away. If the unit is operated too fast, the turf is thrown 4 to 5 feet from the furrow, thereby decreasing the effective width of the fireline. At the proper speed, the turf will roll back and remain at the edge of the furrow, thereby doubling the effective width of the line. The furrow width to mineral soil is approximately 20 in., therefore, with 10 in. of turned up sod on each side of the furrow; the effective width is approximately 40 in.

The plow can be utilized best in areas where there are few, if any, rocks. In dense stands of saplings, where raking a line would be extremely hard, this unit will work effectively; however, line cleanup will be necessary. In areas where it is not possible to plow, the unit has the capability of moving water and tools to remote areas. With a highway speed of 43 m.p.h., it has the advantage of being able to get to a fire quicker than a tractor-plow unit, especially since this unit does not require the use of a low-boy or similar vehicle for transport.

The Unimog 406, with its water and plow capabilities and its complement of hand tools for ground personnel, is an efficient fire-fighting tool. △

FIRE 1970, from p. 7.

a return to the level of 1967. See

Deaths in dwelling fires in 1970 were estimated as approximately 6,500, a decrease of 50 from the previous year.

Property destroyed by fire during the past year totaled $2,710 million, the preliminary NFPA estimates indicate — an increase of $262,400,000 over 1969, and a record high.

Of the property loss total, $2,150 million represents damage to building and contents, and nonbuilding fires—those involving aircraft, ships, motor vehicles, and similar equipment, as well as *forests*—cost about $560 million.

The worst loss-of-life fire in 1970 occurred at the crash of a chartered airliner on November 28 in Anchorage, Alaska, when 46 people were killed. A nursing home fire on January 9 in Marietta, Ohio, killed 31, and a hotel fire on December 20 in Tucson, Ariz., took 28 lives.

The worst property loss fire in 1970 was the destruction of a C5A Galaxy aircraft in Marietta, Ga., at an estimated cost of $30 million; another C5A Galaxy fire, May 25 at Palmdale, Calif., cost $20 million. △

Resource Locators Made of Canvas Are More Flexible

Howard R. Koskella[1]

Resource locators made of metal and wood proved to cumbersome that a new locator made of canvas was developed.

The idea of the resource locator is not new.[2] Most early models of the resource locator were intended primarily for dispatching. Some were made of metal card racks set in a wooden frame which served as a carrying case. Bulkiness and weight made them inconvenient for use in a fire camp, and the need for a lighter, more compact model became evident.

CANVAS MODEL CONCEIVED

BLM and Forest Service personnel at the Boise Interagency Fire Center have developed lightweight canvas models of the resource locator for the plans chief to use. Several Regions of the Forest Service are making similar resource locators. The Boise model is made by stitching a series of canvas pockets on a canvas backing (see figure). Each pocket holds a 5- by 8-in. card. Each locator has pockets for 130 cards; the bottom row of pockets is large enough to hold surplus cards. The overall dimensions of the locator are 36 in. by 54 in., and the top and bottom are fitted with grommets for hanging. It weighs approximately 6 lbs. and may be rolled or folded for transporting or storage.

THE SET-UP

The following is an example of how a locator can be used by the plans chief or his maps and records officer. Cards are labeled for three functions:

1. *Line.* The "present planned line organization" portion of the locator is divided into night and day shifts using labeled cards, depending on existing organizations. The number of divisions and sectors are shown in each shift. The resource card indicaing a specific crew or piece of equipment can be located under

[1] Fire staff officer, Payette NF. Koskella has used the resource locator system on fires in four western regions.

[2] Fire Control Notes, 29 (1): 7, 1968.

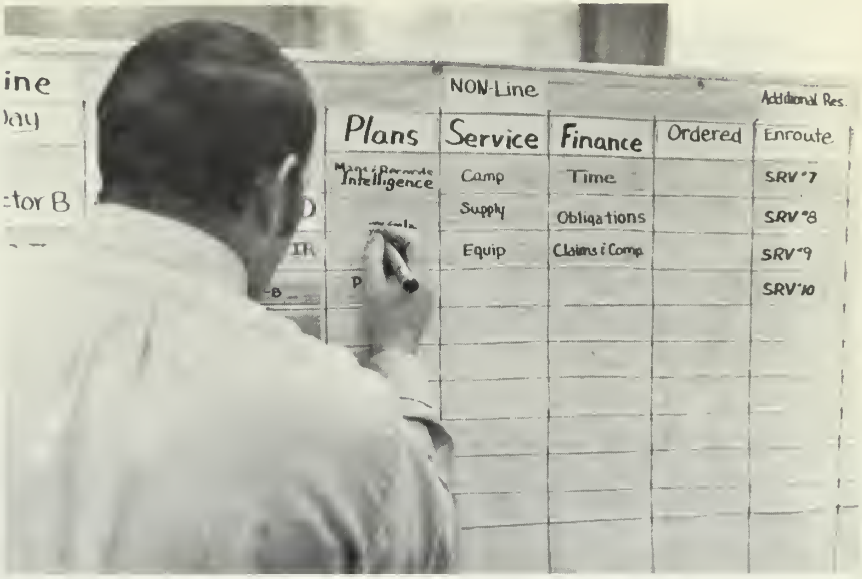
the appropriate shift, division, and sector. If a crew is reassigned, the card is moved to show the new assignment. Reassignments are noted on the lower portion or back of card, providing a record of crew assignments.

2. *Non-line.* This category may be listed in the locator using one card per individual or individuals with similar functions on a card. For example, a single card may list the time officer and several timekeepers.

3. *Additional Resource.* This section of the locator is divided into three subsections labeled *ordered, enroute,* and *available.* These subsections are used to list men and equipment not yet under one of the previous headings. For example, in a strategy meeting the overhead team decides that four more organized crews are needed and the order is placed. The maps and records officer fills in the size and type of crews ordered on four crew cards and puts the cards in the locator under *ordered.* As more information is available, he fills in crew and crew leaders, names, ETA's, etc., and moves the card to a pocket under *enroute.* Once the crew arrives at the fire, their card will be shifted to the *available* section. As soon as the plans chief assigns them to shift, division, and sector, the cards will be moved to the line section of the locator.

A resource locator permits a visible display of all resources assigned to a fire. Fire overhead can review assignments and organization at a glance. Information is easier to use and maintain than that on one-sheet organization charts. The system can be expanded as needed by adding more locators. △

Figure.—This canvas locator, hung from its grommets, is being updated by the fire staff officer.



FAA Reports Fires in Utah

Region 4

In Utah, wildland fire agencies rely heavily on public fire detection and reporting. Each year many fires are observed by aircraft pilots and reported to the Federal Aviation Administration. The FAA then reports these fires to the nearest fire control agency. The Utah Cooperative Fire Fighters (UCFF, a group composed of representatives from wildland fire control agencies) recognized the value of this detection/reporting system but wanted more efficiency in reporting interval and accuracy of fire location and in having the FAA forward the report directly to the responsible agency.

Early in 1970, personnel from the Wasatch National Forest, working with the State Forester and the FAA, devised an improved system of fire location and reporting within the State. Using a Utah base map, 5-inch Forest Service transparent compasses were placed over each VOR[1] station and oriented to magnetic north. When the FAA receives a fire report, the location is determined by magnetic heading and distance from one or more VOR stations. This system eliminates the confusion in attenmpting to convert magnetic headings to true North and in locating by township, range, and section in FAA offices. FAA reporting to the proper fire control agency is facilitated by color-coding on the map and a current list of agency contacts attached to the map.

This method is also used for requesting spot weather forecasts from the Fire Weather Forecaster at Salt Lake City.

This is another example of the outstanding work done by the UCFF to resolve fire problems common to all agencies in Utah. △

[1] Very-high frequency — Omni — Range.

Connecticut Mounts Pump on Bombardier Tractor

J. Leo Cote[1]

Several years back, Connecticut's Forestry Division began using Bombardier J5 tractors in woods operations. Having used these versatile machines a great deal, Ranger Francis Emigh designed and mounted on them a forest fire pump unit to better extinguish inaccessible portions of fires and "way-back" hiker fires.

CONSTRUCTION

Two tanks were made from 3/32-in. steel 60 in. long, 19 in. wide, and 12 in. high, welded on the seams with one baffle in the center. The fronts of both tanks sloped in 6 in. and were mounted forward, up to the protective canopy uprights (fig. 1). Filler pipe of $2\frac{1}{2}$-in. pipe coupling was welded in place well forward and outboard for ease of refilling. A $2\frac{1}{2}$-in. filler plug was used, drilled with a small hole for an air breather when pumping. Short lengths of angle iron were welded to the tank and were drilled through the running boards with four hold-down bolts for each tank. The location of section line fitting is different on each tank. For the left tank, $\frac{3}{4}$-in. coupling was welded in the lower center of the end plate (fig. 2). On the right tank, $\frac{3}{4}$-in. coupling was welded on the lower rear of the inside side plate. This permits a straight-through line in back of the seat cushion to the pump.

A Pacific Marine Type BE pump was mounted on the running board about 18 in. back of the left tank. Three-quarter-inch piping was installed between the tanks and pump, with sections of plastic tubing to prevent breakage from vibrations. Each tank's suction outlet was fitted with a shut-off to permit use of the lowest tank when working on side hills. The units each carried a maximum of 100 ft. of garden hose and an appropriate nozzle.

TANKS HAVE LOW PROFILES

The tanks were designed with a low profile for both low center of gravity and operator safety. The tanks do not interfere with entering or leaving the driver's seat. Testing of balance was thoroughly made both sideways and up and down slopes with full and half loads, and operators tell us changes improved working qualities in the woods. Any changes in re-positioning the tanks, however, may change working characteristics considerably.

The total water capacity of 118 gal. with the low-volume pump will last an appreciable length of time on a fire line.

Rangers agree that the use of this equipment can be a one-man operation if necessary.

UNITS ARE SUCCESSFUL

The two units we have now in operation have been successfully used on more than 17 fires, and we plan to build at least two more. These units are primarily an initial attack tool and should, in seasons of ground fire problems, be used as a delaying and patrol unit on the fire line while the heavier hose lines are advancing. △

Figure 1.—Modified tractor showing tanks and a portable radio.

Figure 2.—Pumping equipment attached to left tank.

[1] Assistant fire control officer, Connecticut State Park and Forest Commission, Hartford, Conn. 06115.

FIRE CONTROL NOTES

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U.S. DEPARTMENT OF AGRICULTURE ● FOREST SERVICE

Gold Ridge Fire Raging on Region 6

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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(NOTE—The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval of any product or service by the U.S. Department of Agriculture to the exclusion of others which may be suitable.)

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1970 Fire Season Statistics : November 30

The number of man-caused fires in National Forests in 1970 was the highest in 18 years. This year, 6,770 fires were man-caused; in 1952, the next highest year, 7,021 fires were man-caused.

Burned acreage, 552,836 acres, was the highest since 1934, or in the last 36 years. The last 5-year average was 182,000 acres/year.

The November 23, 1970, issue of the *National Geographic School Bulletin*, number 11, had a six-page article on fire fighting and the 1970 fire season. The article includes mention of a successful raindance performed last summer by Hopi Indians in California.

On November 25, 1970, as *Fire Control Notes* went to press, two class E fires were burning in California:

Meyers Fire, on the Angeles and San Bernadino National Forests, a reburn, started on November 13th. As of the 18th, 26,000 acres had burned.

Bear Fire, on the San Bernadino National Forest, a new fire also began November 13th. As of the 18th, 54,400 acres had burned, and the fire was contained.

FIRE STATISTICS

Location	Number Fires		Acres Burned			Fatalities	
(Region)	Lightning	Man-caused	NF	Other inside	Total	Number	Cause
1	1,418	400	16,488	1,769	18,257	1	Snag
2	317	208	7,196	672	7,868		
3	2,213	470	25,704	5,442	31,146		
4	788	231	3,460	234	3,694	0	
5	856	1,527	249,364	52,495	301,859	5	Helicopter
						1	Smoke-jumper
6	2,015	1,370	150,929	9,479	160,408	1	Snag
8	145	1,783	15,359	9,671	25,030	0	
9	74	752	1,966	2,605	4,571	0	
10		29	2	1	3	0	
Regional total	7,826	6,770	486,956	82,368	552,836	8	
	(Total number Fires) 14,596						
BLM	(Total number of Fires) 1,805				213,852		
	Acres Burned as of (month)						
S. Cal. State & County	Sept.				324,200		
Washington State	Nov.				61,524		

(figures updated December 1970)

A fireline strategy session on the Mitchell Creek Fire on the Wenatchee National Forest in the Washington State.

THINNING SLASH CONTRIBUTES TO EASTSIDE CASCADE WILDFIRES

JOHN D. DELL[1] AND DON E. FRANKS[2]

Silvicultural practices, such as thinning, can affect the forest microclimate and arrangement of fuels. And any changes in air mass and fuels will affect the start, growth, and behavior of a fire.[3] One result is that fires can flare up more easily, will burn hotter, and can become difficult or even impossible to control. To illustrate the importance of thinning slash, two wildfires that broke out on the same National Forest in eastern Oregon less than a year apart are described.

THE WEIGH STATION FIRE— JUNE 1968

June 11, 1968, was not the kind of day on which you would expect to see a violent wildfire on the pine-covered, relatively flat plateau south of Bend. Minimum humidity for the day was about 40 percent, the maximum temperature, only 65°F; and there was a trace of rain. The fire season can start early here, but it still seemed weeks away. Other events—perhaps a careless traveler discarding a cigarette into dry thinning slash, and less-than-usual winter and spring precipitation, however, collapsed weeks into minutes.

Sometime after 1400, a small fire started in dry grass and needles adjacent to ponderosa pine thinning slash alongside a seldom used dirt road. At 1500, westerly winds accelerated to about 20 miles per hour, and the fire picked up. By 1830, the wind speed had dropped and the tractors were able to complete a line around the fire. By about 2000 all firelines were burned out and the fire was contained.

Despite an all-out air and ground attack effort, the Weigh Station Fire had killed more than 180 acres of thinned, pole-sized ponderosa pine on the Fort Rock District, Deschutes National Forest. Fire suppression costs totaled $20,000. Forest personnel estimated timber resource damage at $15,000.

THE BULL SPRINGS FIRE— APRIL 1969

Less than a year later, on April 16, 1969, another thinning slash fire occurred within the Sisters District on the same national forest where the Weigh Station fire had broken out. The 5-acre Bull Springs fire is believed to have started from a warming fire in an old stump next to a plot that had been thinned in late February—only 8 weeks earlier.

At 1330 the fire was discovered by a forest industry crew. It was spreading through heavy ponderosa pine thinning slash on a 10-20 percent southeasterly-facing slope. Dry bulb temperature at 1430 was 69°F. Relative humidity was 30 percent. Wind speed was 5-7 miles per hour from the northeast. The fire burned uphill with some intensity, but at only a moderate rate of spread. Here again, however, resistance to control was extreme because of the volume and arrangement of slash on the ground.

Hand crews could not work their way through the heavy slash, and tractors were re-

Figure 1. — Untreated slash from precommercial thinning is ready-made fuel for the ignition and spread of wildfire. Resistance to line construction and potential rate of spread in these heavy fuel accumulations are considered extreme (E.E.)

[1]Forester, formerly with the Pacific Southwest Forest and Range Experiment Station, Berkeley, California; now with PNW Forest and Range Exp. Sta., Portland, Oreg.

[2]Fire dispatcher, Deschutes National Forest, Bend, Oreg.

[3]Countryman, Clive M., and Mark J. Schroeder. Fire environment—the key to fire behavior. Proc., Forest Prot. Div., Fifth World Forest. Congr. 4 p., illus. 1960.

quired. The fire spotted across a road at the top of the slope, where there was no thinning slash—only scattered manzanita. Ground tankers extinguished this slopover with little difficulty. The fire was finally contained at 1600 by Forest Service and Oregon State Forestry Department crews. About 80 percent of all trees in the thinned stand were killed by the fire.

OTHER FIRES

Later in the summer of 1968, portions of several large wildfires in eastern Oregon and Washington burned through similar pine thinning slash areas. The Marks Creek fire (Ochoco National Forest, July 5-8) and the 4th-of-July Mountain fire (Wenatchee National Forest, August 4-10) received much of their impetus in this fuel type.

DISCUSSION

When dense, young conifer stands are thinned their effect on fire control is still debatable: For example, Fahnestock[4] concludes that precommercial thinning in ponderosa pine stands seriously increases fire hazard for at least 5 years. He pointed out, however, that in the long run thinning greatly reduces the vulnerability of stands to fire. Cron[5] cites three cases in which thinned stands, with thinning slash on the ground, aided in controlling fast-spreading fires under extreme burning conditions (these conditions were not described). Appleby[6] maintains that it is not possible to generalize about fires in thinning slash. Weather, fuels, and topographic conditions in each fire must be considered to make valid comparisons of fire control in thinned and unthinned stands.

Contributing Factors

Several factors contributed to the origin of the two principal fires described here. Lack of precipitation was one. Between September 1967 and June 1968, only 5.63 inches of rainfall and 15 inches of snowfall were recorded at Bend, Oreg.—about half of what is normal for this period. Between February and June, only 1.5 inches of rain fell, with only a trace of snow.

In the months before April 16, 1969, about 10 inches of rain and 75 inches of snowfall were recorded in nearby Bend. Although total precipitation was normal for this area, snowfall was more than twice the average for the period. But in the 30-day period before the Bull Springs fire started, only a trace of snow or rain was recorded.

The second factor was the presence of thinning slash. For instance, almost all area burned by the Weigh Station Fire—except at the actual point of origin—had been covered by dense 3-year-old thinning slash with needles still intact on the branches (fig. 1). Trees had been thinned to a 16- by 16-foot spacing. Using Fahnestock's method[4], we estimated 35 tons of slash per acre, or 6,300 tons for the 180 acres burned.

The third factor was the moisture content of needles, branches, and twigs. It was estimated to be less than 30 percent in the Weigh Station Fire, making these materials highly susceptible to burning. Rate of spread and resistance to control in this fuel was rated extreme (E.E.).[7]

Fuel moisture samples were collected a few weeks after the Bull Springs Fire from thinning slash in a nearby stand that had been thinned at the

[4]Fahnestock, George R. Fire hazard from precommercial thinning of ponderosa pine. USDA Forest Serv. Res. Pap. PNW-57, PNW Forest & Range Exp. Sta., Portland, Oreg., 16 p., illus. 1968.

[5]Cron, Robert H. Thinning as an aid to fire control. Fire Contr. Notes 30(1): 1. 1969.

[6]Appleby, Robert W. Thinning slash and fire control. Fire Contr. Notes 31(1): 8-10. 1970.

[7]Based on Guide for Fuel Type Identification—R-6 (1968). U.S. Forest Serv., Portland, Oreg., 48 p., illus. 1968.

Figure 2. — A wildfire in dense ponderosa pine thinning slash has consumed the ground fuels and killed the standing trees. The fire was so hot, a coating of ash was left on the ground. Note silver hard-hat on stump, left center.

same time. Moisture content in the finer fuel components was 50 percent. This and the intensity of the fire suggest that green thinning slash had cured rapidly to a low moisture content and a highly flammable state, even though it was spring.

Fire Spread and Resistance to Control

Shortly after it started, the Weigh Station Fire—influenced by the fresh westerly wind—began spotting into thinning slash. The spot fires rapidly burned together, and the fire then pushed easterly in an intense front. It burned mostly on the ground in the slash, but occasionally crowned through the spaced trees in the thinned stand.

The dense thinning slash was almost impenetrable to hand crews with cutting tools. Direct attack on the fire was impossible. Handline construction on the flanks was too slow and difficult to keep up with the rapid spread of the fire. The dense slash also hampered the ground tanker attack. When tractors arrived on the scene during the Weigh Station Fire, the ground crews were used for line holding.

In a wildfire of such intensity, almost no ground fuels are left, and most of the standing trees are killed (fig. 2).

CONCLUSIONS

As we see it, most of the emphasis in these differences in viewpoints has been on the ease or difficulty of *controlling* a moving wildfire in thinned stands. Equal consideration should be given to the *ignition and spread potential* that exist in heavy accumulations of dry thinning slash. One goal of good forest management is to prevent wildfires from starting at all, but if they do start, management should be able to control them at a minimal size.

The two fires described in this paper are graphic examples of the ease with which a fire can *ignite* and *spread* in ponderosa pine thinning slash. If weather and fuel conditions are the least bit critical when a fire occurs, the investment in having thinned the stand—and the stand itself—may be lost entirely. Foresters must recognize this possibility, and plan counter-measures as precommercial thinning progresses. Such measures might, where feasible and economical, include treating thinning slash by mechanical crushing or chipping.

In some areas, extra fire patrol or protection may be necessary. Forest managers should consider topography, cleaned buffer zones, use of natural barriers, and adjacent fuel types when they plan for thinning. △

Fire Occurrence Mapped by Computer

A. T. Altobellis,

C. L. Shilling, and

M. M. Pickard [1]

Maps showing fire occurrence patterns are used extensively by prevention administrators and researchers, but preparation and updating are tedious and time consuming. A computer program is now available that prepares fire occurrence maps for areas in which fire locations are based on the U.S. public land survey system. From cards prepared for individual fires, the computer totals the number of fires per 40-acre block and prints the totals on a township overlay with a scale of 1 inch per mile.

For each fire, county name and code number, township, range, section, and code number for the forty-acre legal subdivision within the section must be punched on a card. The cards may be filed by township, county, or larger area. The program, written in FORTRAN IV, G LEVEL, scans the card deck for fires in the township(s) of interest and prints an overlay of the number of fires up to nine that have occurred in each "forty" in the township. An **X** is printed to indicate more than nine fires. Unless data are being plotted for a long period of time, e.g., more than 5 years, the limit of nine fires per "forty" is seldom reached. For most purposes, this limit does not detract appreciably from the usefulness of the overlays.

States Not Under Survey

In many States that are not under the public land survey system, fire control organizations have a grid system for locating fires. With some alterations in coding, the program can be adapted for use in these States.

Program source decks and test data are available on request from the Fire Prevention Project, Southern Forest Experiment Station, P.O. Box FX, State College, Miss. 39762.

△

[1] Altobellis and Shilling are research foresters, Southern Forest Exp. Sta., USDA Forest Service; Shilling is currently enrolled in the Dep. of Recreation and Parks, Texas A & M Univ., College Station, Texas. Pickard is a graduate assistant in the Computer Sci. Dep., Miss. State Univ., State College, Miss.

DIAMMONIUM PHOSPHATE PREVENTS ROADSIDE FIRES

JAMES B. DAVIS [1]

Application of DAP retardant resulted in reduction of average fire occurrence along the Ridge Route on the Angeles National Forest. Evidence is being found that reduced flammability in treated grass areas is significant.

Mix high-risk, flashy fuels along a highway with a long, hot, dry summer and you have an explosive combination: This is the situation where U.S. Interstate Highway 5 crosses the Angeles National Forest in southern California. In 1964 more than 6 million vehicles sped over this 9-mile stretch of highway known as the Ridge Route (fig. 1).

And where you have people, you usually have fires. In fact, the Angeles National Forest used to record annually as many as one fire per mile for this route, or about one-fourth of all the wildland fires on the Forest. This is not so today. The traffic has increased to nearly 9 million vehicles, but during the past 5 years the number of fires has averaged less than two per year for the entire stretch of highway (table). What makes the big difference? The roadside application of chemical fire retardants may be the answer.

[1]PSW Forest and Range Exp. Sta., USDA Forest Service, Berkeley, Calif.

Hazard reduction is not new

Hazard reduction has been practiced on the Ridge Route for many years. Since 1955 hand crews removed all vegetation for 6 to 10 feet on each side of the highway. Yet, fire starts continued—the usual methods of hazard reduction just weren't enough.

DAP Use is new

William Beaty, Angeles fire control officer, wondered if it was possible to deal with the problem by fireproofing the fuel just beyond the cleared area. Then fires that did start would burn slower, allowing fire control personnel to restrict fires to the A or B size class. He knew from studies conducted by the Pacific Southwest Forest and Range Experiment Station that diammonium phosphate (DAP) solutions—used in many cases by airtankers—sprayed on roadside vegetation could make it fireproof.[2]

Station researchers found that grasses treated with DAP at the rate of about 2 pounds per gallon of water applied at the rate of 2 gallons for each 100 sq. ft. would burn slowly. And in some cases, grasses would not burn at all.

[2]Dibble, Dean L. Roadside hazard reduction with fire retardant chemicals. U.S. Forest Serv. Res. Note PSW-N21, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 9 p. 1963.

Figure 1.—Rough topography, flashy fuels, and heavy traffic combine to create a serious fire problem on the Ridge Route of the Angeles National Forest in southern California.

A big drawback is that DAP is soluble and can be washed off by as little as ¼-inch of rainfall. However, the Ridge Route receives only 8 to 12 inches of rainfall annually and almost none of it during the summer fire season. Therefore, the lack of summer rainfall—so important to the fire problem—made feasible the use of fire retardants.

Before treatment, the area was averaging 4.7 fires per year (9 fires in 1964) at a suppression cost of at least $10,000 annually. Beaty estimated that spraying both sides of the 9-mile strip would cost about $1,000. If the number of fires could be reduced by 10 percent, then suppression costs would be offset, and the subsequent reduction in damages would be a bonus.

5-year try

Beaty decided to treat the fuels along this stretch of highway for 5 years and then evaluate the results. For the years 1965-1969 the fuel removal continued, but in addition, crews sprayed the adjacent grass fuels with a DAP mixture for 15 to 30 feet beyond the cleared area as topography and plant cover required.

Results? Yes!

The results were far better than Beaty had hoped. Fire occurrence was reduced from 4.7 to an average of 1.6 per year. A simple test showed that this was a statistically significant reduction in fire occurrence.[3]

More important—no fire escaped. Previous to treatment, the Ridge Route had been an area where destructive fires often got started on the Angeles National Forest. After the treatment, the Ridge Route had no fires larger than 1 acre—chiefly because fires that did start burned slowly. In one case, the fire crew arrived to find the fire barely creeping, and several bystanders wondering why the dry grass was not burning well in such hot dry weather.

Frankenstein monster?

DAP is an effective fertilizer. Anybody who has had experience with range fertilization might well ask: "What effect is all this DAP going to have on the volume of grass growth? Aren't you going to create a Frankenstein monster by increasing the fuel volume?" While there has been some growth increase on some of the test plots set up elsewhere in California by the Pacific Southwest Station, it has not been a problem on the Ridge Route. Probably other factors, such as low rainfall or the shortage of other grass nutrients, are limiting.

An interesting speculation is that the Angeles National Forest may be favoring slow-burning grass. A chemical analysis of green grass growing on an area treated for the past 4 or 5 years but not treated immediately prior to analysis shows a significantly higher phosphate and total ash content than grass growing outside of the treated area. This indicates the retardant is being absorbed by the roots. Total ash content for six sample areas that were treated averaged 10.7 percent of dry weight. Shadscale, saltbush, and fourwing saltbush are species considered to be slow-burners because of their high ash contents (10 to 20 percent). On the other hand, ceanothus, big sage brush, and chamise—species considered flashy fuel—have low ash contents ranging from about 3 to 6 percent.

Questions

Some questions that need to be answered are:

1. Under what soil and rainfall conditions will DAP applications produce more fuel because of fertilization?
2. Will the persistence of DAP in the topsoil consistently increase the phosphate and total ash content of the new grass crop and result in reducing its flammability? This growth could contribute to the development of slow-burning vegetation. The value of such a characteristic in vegetation is obvious.
3. What will be the effect on vegetation compositon? California's annual herbaceous vegetation varies from year to year and site to site. Selective range fertilization can change the composition greatly. Range fertilization programs using phosphates have produced increases in broad-leaved plants, such as clovers, that tend to be much less a fire problem than the more flashy annual grass fuels.
4. What other treatments might yield greater results or cost less? The Angeles National Forest is getting equipment which will enable its fire crews to apply the DAP mixture more economically at a variety of sites. The unit was developed by the Forest Service's Equipment Development Center, Missoula, Mont. The

Table.—*Number of fires on Ridge Route, Angeles National Forest, California, by years and size-class, 1960-69*

	SIZE-CLASS					
Years	A	B	C	D	E	Total
1960-64	23	6	3	0	1	33
1965-69	6	2	0	0	0	8[1]

[1]Fire retardants used in 1965-69.

[3]The *t* test of the difference between two means was significant to the 5 percent level (18 degrees of freedom).

unit resembles an orchard sprayer and should be a major improvement over the tank trucks previously used.[4]

The Angeles National Forest is now using DAP as an operational treatment for drier parts of the Forest if the principal fuel is dry grass. The retardant should be effective on campgrounds, where fuel removal can cause a problem of dust; in work areas, such as construction projects, where work will be able to be continued even during periods of high fire danger; and on fire lines, where retardants will be used to widen or supplement other forms of line construction.

Are retardants for you?

But whether retardants would be effective in these other places will depend on fire incidence, values threatened, length of treatment, and rainfall pattern. Frequent summer rainfall would probably require repeated treatment. Repeated treatments can be justified when values are high enough. For example, the U.S. Army has repeated treatments of diammonium phosphate on a missile test range near Monterey, Calif. The purpose of the treatment is to keep the vegetation in its natural conditions yet prevent fires from destroying expensive instrumentation located throughout an impact area.

On the basis of 5 years' results at Ridge Route, I suggest that if you have an area where values are high, fire incidence great, and rainstorms few and far between, perhaps you ought to consider chemical retardants as a means of preventing fires. △

[4] Jukkala, Arthur H. High volume retardant sprayer. Fire Contr. Notes 30(1):4&11. 1969.

Air Horn Helpful in Fire Emergencies

Albert G. Bell [1]

The lookout posted on a vantage point observing the fire's behavior is the eye of safety of his crew. Because of the shortage of fireline radios, the lookout has only hand signals and word of mouth to alert his crew of danger. But we felt we needed to provide the lookout with another means of communication.

The Southwest Forest Fire Fighters Interagency Council (SWFFF) discussed this safety problem at their annual meeting in Santa Fe, N. Mex. This council consists of one representative from each of the following agencies: National Park Service, Region 3; Bureau of Land Management; State of New Mexico; USDA Forest Service, Region 3; Bureau of Indian Affairs, Albuquerque Area; and New Mexico Department of State Forestry.

The SWFFF Interagency Council has the responsibility of establishing policies and procedures for the performance, training, safety, and equipment as related to organized Southwest Forest Fire Fighting crews.

Air horn suggested

The National Park Service representative, Tom Ela, recommended that all SWFFF Crew Liaison Officers should be issued a manual type air horn when dispatched on a fire detail. This suggestion was adopted and implemented for the 1970 Fire Season.

Several models and types of air horns were reviewed and tested. The Falcon, model no. U-4, was selected because of its size and audibility (fig. 1). This particular model weighs two pounds. Cost of this model is $15.25, complete with horn, valve, gas supply, and belt clip. Replacement gas supply cans are available for $1.95 each.

Special instruction labels are attached to each horn (fig. 2) and specific operating procedures are also included with the crew liaison officers' instructions. It is our intent the air horn will only be used to notify the crew to evacuate to a safe area via a pre-planned escape route. It is very important that the horn is not used for any other purpose. If coded signals were used for other purposes, the horn would soon become inadequate for evacuating crews under blow up conditions.

Gary E. Cargill reports the

see Air Horn, p. 15.

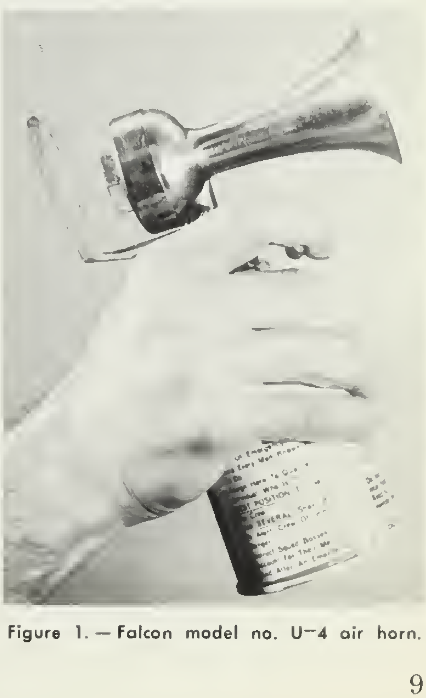

Figure 1. — Falcon model no. U—4 air horn.

[1]Fire dispatcher, Region 3, USDA Forest Service.

℞ for Burning On Apache National Forest

Bill Buck [1]

The Apache National Forest in the Southwest is zeroing in on prescriptions for successful prescribed burns. Manpower, timing and physical layout are important considerations in planning a prescribed burn.

Logging and pulp slash. This hottest burn had a convection column well developed to 10,000 ft. above ground surface.

The Apache National Forest, like many southwestern forests situated on the Colorado Plateau, has significant fuel hazard problems. The extensive fuel accumulations in these coniferous forests are the product of several factors: the climate of the Southwest; the history of forest use by stockmen and loggers, creating an environment favorable to the establishment of extensive "doghair" (Black Jack) thickets; and the steadily increasing logging operations, for which the needed slash cleanup has not been adequately financed.

How much in a year?!

The Apache acquires 40,000 acres of new slash fuels each year, with an average of 45 tons of dead fuels per acre. Vast acreages on the Apache actually have two or more deposits of slash—resulting from successive cuttings since the early 1950's. If we are to correct this excess, we must make successful use of prescribed fire.

The Apache initiated its prescribed burning administrative studies in 1967. Under the direction of Harry Nickless, District FCO, 400 acres of the Iris Springs project were burned on the Springerville Ranger District in November.

Prescriptions for Fires

In 1968, we modified the Iris Springs prescription and burned additional acres. The results of these prescribed burns were successful enough to be helpful to other foresters with similar problems. We burned 800 acres at a cost of $2.50 per acre and stayed within justifiable mortality limits.

The table, on the next page, compares the statistics of three block burns in the Iris Springs Burn. Comments on the burn are included, and indicated optimum prescriptions are given.

The following tabulation indicates the prescription that will work in our situation:

Temperature	- Maximum 50°F.
	- Minimum 40°F.
Relative humidity	- 30-40%
Fuel moisture sticks	- 20%
Wind	- 10-15 m.p.h. (steady)

To some degree, trade offs can be made between prescription elements; lower temperatures and higher relative humidity than those prescribed could be satisfactorily offset by strong, steady winds or by using slope and firing techniques in your favor.

Mortality Strips

In the most severe scorch area, mortality strips one year after the Iris Springs burn revealed these losses:

1½% of the stems over 6 in. d.b.h.

16½% of the stems 3 in. to 6 in. d.b.h.

18% of the stems under 3 in. d.b.h.

36% was the total loss (30% of this 36% was in the suppressed or intermediate trees).

The loss represented 15½

[1]Fire control officer, Apache NF.

percent of the basal area, 10 percent of the 15½ being in the suppressed, intermediate class.

Another sample taken in an unthinned site (Loop Burn) revealed 45 percent of the total stems were lost—41 percent of which were under 3 in. d.b.h. and which had been suppressed to a basal area of 99 sq. ft. On a high Class II site index, 74 percent of the total trees were left.

Our Objective

Our objective is to compile a catalog of proven prescrip-

Canyon Bottom thinning slash: *Above;* Before burn; thinning stem, 3 in.; fuel moisture, 7½%; temperature 40°F.; relative humidity, 50%. *below;* after burn, some location; note end of log in both pictures.

Table. — Statistics of the 1968 Iris Springs Burn

CONDITIONS	BLOCK NUMBER 6	10	4
I. Record of actual burn			
Acres in block	30	60	30
Fuel type	Ponderosa Pine with 3 & 4-year-old logging slash	same with 3-year-old logging slash	same with 3-year-old logging slash
Fuel loading	Heavy Over 30 tons	Heavy Over 30 tons	Average 30 tons/acre
Aspect	SE	E	SE
Slope	20%	30%	15%
Observed weather			
Temp.	40°-43°F.	38°-46°F.	32°-41°F.
Relative Humidity	38%-44%	20%-40%	28%-32%
Wind	15-25 m.p.h.	5-10 m.p.h.	0-5 m.p.h.
Fuel moisture (½-in. Stick)	30%	20%	15%
Firing method	We utilize strip head firing primarily, working down slope on the contour. This technique gives us optimum control and flexibility.		
Fire behavior observed	Hot, parallel to wind cool, against wind	Ideal burn, little too hot at 1400	Too hot in places, scorch and crowning
Fuel Consumption by percent			
Light	70	90	80
Medium	40	60	60
Heavy	30	30	20
Duff	Average depth in all three blocks—3 in. Consumption averaged 1 in. in depth with complete consumption beneath and adjacent to fuel concentrations.		
Comments	The gusts rather than the high winds seemed to do the only damage. The high winds would fan the fires in the pulp tops to high temperatures; then the wind would quit, allowing vertical dissemination of heat into the tops of the pole stand.	Ideal burning conditions. Very little scorch or kill.	Fuel moisture may have gotten a little too low. Also lack of wind contributes to "baking" the crowns. The aspect seemed to have considerable affect.
II. Indicated Optimum Prescription			
Temp	43°F.	40°F.	35°F.
Relative Humidity	38%	30%	30%
Wind	15 m.p.h.	10 m.p.h.	10-15 m.p.h.
Fuel moisture (½-in. stick)	20%	20%	20%

tions to burn any given site in the pine type. Each prescription will vary, dependent upon the basic ingredients of slope, aspect, weather, fuel arrangements, fuel densities, character of residual stand, and the desired density and composition of the residual stand when completed. And, in order to reach our objective, several factors have to be considered.

Men are important, too

The prescription alone doesn't get the job done. Of first importance is men. The men selected as your torch men must develop a "feel" for the job. They must know when to slow or accelerate the ignition rate; how much heat they've got going and if it is for or against them; and when they need more fire momentum, how to get it, and how to break it (firing techniques).

What does it look like?

Another important factor is the negative aspect of a scorched stand. We must realize we can't burn on a production basis without some degree of mortality. We are not going to get 100 percent consumption of ground fuels with a cool burn.

Money Matters

Financing has to be programmed. To plan a burn relying on contributed labor is wishful thinking. You must be guaranteed ahead of time the right manpower will be on hand when you need it—and on short notice. This requires approved financing.

When to Burn

It is important to recognize when you can safely burn. For the Apache, the time is late October and November. This puts us just past the fall drying trend and into the cooler temperatures and shorter days before our first winter storms. This is the time of year when the perennial grasses are cured, offering the flash fuels necessary to carry the fire. We begin our burns 1 to 4 days following light precipitation, which allows the light fuels to pick up then lose the necessary fuel moisture for a medium spread factor.

Logical layout

The physical layout of your project must be logical. Individual blocks must be laid out so that they can be totally ignited and held, within 4 hour periods. Generally this means about an 80-150 acre block for a four to six man crew. Fuel arrangement, density, and moisture content; topography; cultural features; and aspect of slopes will all effect block layout.

Conclusion

Prescription burning can be a successful and practical solution to much of the fuel hazard on the Apache. Our work so far indicates we are nearing the desired prescriptions, while within justifiable losses of the residual stand and within economic limits. △

Lagging taps: *Abcve*, Intermingled with repraductian; *below*, tarching aut, reducing residual stand. This is the mast difficult situatian ta cape with because such fuel arrangements invariably mean lass af patches af trees.

Flexible Plates For Simulators Found Feasible

H. P. GIBSON [1]

The standard method of producing the flame and smoke patterns in the fire simulator is through the use of painted glass plates. The paint is scraped off the plate in a pattern which will produce the desired outline on the background scene on the screen.

While the flame and smoke patterns are satisfactory, the plates themselves have a number of disadvantages. They are subject to breakage. They will damage the simulator if accidentally dropped through the plate opening. They must be cleaned and repainted. Their bulk and brittle nature makes it impractical to store simulator exercises with prescribed plates. For this reason, it is impractical for a headquarters unit to supply prescribed plates with exercises to be used on simulators in field locations.

What's needed?

Some criteria for selecting an alternate material for simulator plates are:

1. It should be a transparent material precoated with a durable, scribable coating.
2. It should be flexible enough to withstand handling in the mail.
3. It should be thin enough to make storage in file folders practical.
4. It should lend itself to photographic reproduction.
5. It should be soft enough to cut with scissors.

This may be the answer

There a number of products which fit these criteria. One of them is a drafting supply film made by Keuffel & Esser Co. It is their Stabilene Film© called Scribe Coat©, #443207. This is a coated flexible film obtainable in either .005 in. or .0075 in. thickness. The white coating readily accepts ordinary pencil and is easily scribed with a sharp knife blade (fig. 1).

When the film is used, all glass simulator plates are thoroughly cleaned and left in place in the simulator. The film is cut to the exact size of the glass plates and taped over them with masking tape. Masking tape will not pull the coating from the film.

The film may be etched with a sharp knife blade while the exercise is in progress. This method is suitable for producing fire, smoke, and symbol. K&E produces a touch-up fluid which may be used to cover etched areas. It is applied with a small brush. This is their catalog item #582100. Their clear, uncoated .0075 in. Stabilene Film© may be used with the touch-up fluid to produce char.

Uses

The use of this coated film will make it practical for the Fire Control Training Officer to design simulator exercises, scribe the plates for each exercise, and store them in ordinary file folders for immediate use. Pre-scribed plates are masked with constuction paper at the beginning of the exercise, and the masks are withdrawn as the fire spreads.

With the general use of the new COMPACT Fire Simulator and flexible plates, standardization of hardware in the simulation field will be possible for the first time.

Figure 1. — Scribe Coat© plate, standing on edge, shows etched pattern. In position on the command simulator is a photo reproduction of the Scribe Coat© plate

Duplicate Plates

The Fire Training Officer may now produce simulator exercises with prescribed plates for distribution to field stations. The scribed film plates may be copied on a light table.

Quantities may be produced photographically by using the original as a negative and producing film positive prints in the darkroom. A clear edge may be left on the photographically duplicated plates to facilitate proper location on the simulator (figs. 1&2). Scribing on the reproductions may be covered with the touch-up fluid, but additional scribing cannot be done.

How much will all this cost?

The film and touch-up fluid are described in K&E Catalog #3. The cost of the scribe coat plates would be approximately $.35 to $.70 each, depending on size. This is not excessive considering the cost of moving a glass plate to a suitable work area and cleaning and repainting it. △

[1] Director, National Fire Training Center, USDA Forest Service, Marana Air Park, Marana, Ariz.

1970 AUTHOR INDEX

Note: First figure is issue number; second is page.

1970 SUBJECT INDEX

△

AIR HORN, from p. 9.

successful use of the air horn on the Soldier Fire, Tonto National Forest, July 6, 1970.

Planned escape routes and signals were thoroughly discussed before the crews were committed to the line. Thus, without radio communication, firefighters alerted by the air horn reached safety when their position was outflanked by the fire.

In this instance, the large canyon and Four Peaks acted as a huge amphitheater, amplifying the sound. However, the opinion of overhead was that the air horns would be loud enough to be heard, even under less favorable acoustics.

This was a good example of effective communications without radios. When planned in advance, lookouts, hand signals, and air horns can be combined to provide for safety first in aggressive firefighting. △

BLACK DAYS, from p. 16.

low relative humidities. When these conditions combined with an unstable atmosphere, all conditions were "go" for blow-up fires. And blow-up fires did occur.

At 9 p.m. that Black Wednesday evening the Ouachita National Forest called to report one of their worst fires in 3 years had been burning out of control. Aerial tankers, as well as hand crews, had been ineffective against this fire. The Oklahoma Division of Forestry reported a total of 35 fires that burned 7,669 acres, while one fire roared over 2,080 acres. Arkansas (State and National Forests) had a total of 142 fires which burned 12,559 acres.

Air Stability the Key

When fire weather conditions are conducive to many fires (i.e. large precipitation deficiency, and low relative humidities) the fire weather meteorologist gives special attention to the stability of the atmosphere. The key to identifying this situation is interpretation of the early morning radiosonde observation, including temperature, humidity, and wind from the ground upward, thousands of feet. The fire control agency, informed of dangerously unstable atmospheric conditions by the fire weather meteorologist, is warned to expect erratic fire behavior. △

BLACK WEDNESDAY
in Arkansas and Oklahoma

ROLLO T. DAVIS AND RICHARD M. OGDEN [1]

During the more critical fire seasons there always seems to be one or more days that stand out as "black days." On these days fires burn hotter and are harder to control than on other days. Fires blow up on "black days." Like Black Wednesday, April 8, 1970, in Arkansas and eastern Oklahoma.

Fire Season

The fire season in both states usually ends in late April. Normally by this time, vegetation is turning green. Fire control agencies are shifting to other forestry operations, and seasonal fire control crews are leaving. But April 1970 was unusual.

Rain fell in above-normal amounts during the early spring months. Periods of rain were so spaced that all fuels, except the fine ones, remained wet. Temperatures remained well below the seasonal normal keeping the vegetation in the cured stage. Except for a few border stations, fire danger stations did not go into the transition stage until mid-April. Rainfall, that had been coming in substantial amounts, dropped off in late March to almost nothing. This dry spell continued into mid-April and temperatures started rising to more normal levels. This was just the type of weather the people were waiting for: to begin field clearing by burning, brush pile burning, and garden and household debris burning. During this period, a great number of fires roared out of control.

Synoptic Situation and the Black Wednesday Forecast

The dry spell, begun in late March, stretched into April as dry, high pressure spread over Oklahoma and Arksansas. It blocked frontal systems from the area. By April 7, high pressure extended upward to 20,000 feet, but the surface high center had moved to the lower Mississippi Valley. Moderate-to-strong, southwesterly, low-level winds pumped even drier air over Arkansas and Oklahoma. Afternoon relative humidities dropped to the 20-percent level, and some places had humidity readings down in the 'teens. With fuels already bone-dry, an extremely dangerous fire situation was in the making. Fires by the hundreds were being reported in Arkansas and Oklahoma. But most of them were not too difficult to control.

Wednesday morning, April 8, another dangerous weather feature entered the weather picture. The 6 a.m. radiosonde observations at Oklahoma City and Little Rock showed the air to be conditionally unstable to about 15,000 feet. It would become absolutely unstable from the surface up to 4,000 feet by the middle of the afternoon. Widespread surface whirlwinds or dust devils resulted from the great instability in the lower 1,500 feet. Warnings were called to the State Fire Control Chiefs, as well as to the Ozark and Ouachita National Forests. The warnings were for potential blow-up conditions. Hard-to-control fire behavior such as rapid crowning, long-distance spotting, and large convection columns was expected.

What Happened

All conditions were favorable for fires in Oklahoma and Arkansas. There was a significant deficiency in rainfall during the last half of March and the first half of April. There had been an extended period of extremely

see BLACK DAYS, p. 15.

[1]Forestry meteorologists, NOAA, National Weather Service, Oklahoma City, Okla., and Little Rock, Ark.